Appendix 6.9.8

Y/DD-896/R1, *CRITICAL EXPERIMENT BENCHMARK CALCULATIONS WITH CSAS25 FROM SCALE4.4a FOR CRITICALITY SAFETY ANALYSES ON THE HP J-5600 UNCLASSIFIED WORKSTATION (CMODB)*
AND
Y/DD-972R1, *DETERMINATION OF THE UPPER SUBCRITICAL LIMIT FOR CRITICALITY CALCULATIONS FOR CRITICALITY SAFETY ANALYSES*

BWXT Y-12
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Y-12 NATIONAL SECURITY COMPLEX

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BWXT Y-12, L.L.C.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Critical Experiment Benchmark Calculations With CSAS25 from SCALE4.4a For Criticality Safety Analyses On the HP J-5600 Unclassified Workstation (CMODB)

Revision 1

R. H. Smith

Nuclear Criticality Safety
Y-12 National Security Complex

August 2003

Prepared by the
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Managed by
BWXT Y-12, L.L.C.
For the
U.S. Department of Energy
under contract DE-AC05-00OR22800

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Y/DD-896/R1

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Revision Log

Revision Number	Description of Change	Pages Affected
1	Removal of results for 27 and 44-group library, for Volumes II-HEU and IV-LEU. Inclusion of results for Volumes I-Pu and VI-mixed U/Pu, which were previously published in Y/DD-996/R1. Addition of new results for Volumes III-IEU and V-U233. Addition of new results for Volume II-HEU, including models developed as part of the qualifications program. Editorial Changes.	All

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Abstract

This report documents calculations performed for validation of the CSAS25 control module from the SCALE 4.4a computer code system for use in evaluating nuclear criticality safety. This revision includes results from using only the 238-group ENDF/B-V cross-section library. The criticality validation calculations were performed using over 1200 benchmark cases from Volumes I through VI of the "International Handbook of Evaluated Criticality Safety Benchmark Experiments," published by the Nuclear Energy Agency Organization for Economic Cooperation and Development (NEA/OECD) [i]. This revision collects all the OECD benchmarks modeled by Y-12 Nuclear Criticality Safety into one report. Based on the results, the CSAS25 module and 238-group library are validated for use with systems that are similar to those included in this validation. Establishment of sub-critical limits will be documented in a separate report.

The original version of this report included about 500 cases from Volumes II and IV (HEU and LEU). Subsequently, about 400 cases from Volumes I and VI (Pu and mixed U/Pu) were documented in Y/DD-996/R1, and these results are now also incorporated into this revision. In addition, new results for Volumes III-IEU (51 cases) and V-U233 (140 cases) are now included. Finally, 53 new results for Volume II-HEU, including 26 models developed as part of the qualifications program, as well as 32 new results for Volume IV-LEU, including 7 from the qualifications program, have also been added. In total, 276 new models were added in this revision, for a new total of 1217 models.

Results for 27 and 44-group libraries, for Volumes II-HEU and IV-LEU, have been removed. The 238-group library was previously shown to have generally superior results, and experience has now shown that any disadvantages, such as somewhat higher computer run-time and memory requirements, are not a major problem with newer computers. Therefore, only 238-group results are included in this revision.

Although many cases are included in this report, analysts are cautioned that they must not assume that all SCALE input options are validated for all applications. They must verify or demonstrate that their options are validated against benchmark experiments that are similar to their applications. Options include material selections (e.g. "be" versus 'bebound"), scattering options (i.e. SCT), geometry options (i.e. infinite homogeneous, multi-region, or latticecell), and others. Experience has shown that seemingly minor differences (e.g. 'bebound" versus "be") may cause large changes in results, particularly when errors exist in cross section libraries.

Acknowledgements

In addition to the principal authors and reviewers, a number of people participated in this revision effort and provided valuable help, comments or suggestions. In particular, analysts working on Y-12 calculation qualifications prepared approximately 33 new HEU models, which have been included. These analysts were Julie Ezold, Bryan Johnson, Susan Osterhout, Max Robinson and John Sherwood. Other contributors include Allan Krass and John DeClue. Comments from Andy Szaflarski and Cris Worley were also appreciated. Finally, we could not have completed this work without the reliable workstation operation and system administration by Anthony Wheaton.

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1 Introduction

In nuclear criticality safety engineering, extensive use is made of computational methods for analyzing the calculation models of physical systems. The successful application of computational methods requires verification, certification and validation (V&V) of the analytic tool. Software verification, the first element of V&V, reveals the closeness in agreement between calculation results obtained using a particular computational method and calculation results obtained using other methods. Software certification provides a user assurance that the code will consistently produce numerical results that agree with analytic solutions for the problems the code is designed to analyze. Software validation "calibrates" the calculation results obtained using certified software (computational method) for agreement with the physical universe.

The refinement of a validation or extension of it by the addition of cases does not require re-certification of the software. Therefore, the verification and certification of the SCALE 4.4a modular code system are separate issues, and are published separately. This document addresses the calculation results to be used for establishment of bias, bias trends and uncertainty for validation of the CSAS25 control module from the Standardized Computer Analyses for Licensing Evaluation (SCALE) Version 4.4a package with the 238-group ENDF/B-V SCALE 4.4a cross-section libraries.

Section 1.1 identifies source documents and rationale for the validation activities, and it summarizes the scope of the validation performed on the Nuclear Criticality Safety Division (NCSD) Hewlett Packard Series 9000/J-5600 (HP J-5600) unclassified workstation (referred to as CMODB) at Y-12.

1.1 Validation of CSAS25 in SCALE 4.4a for Criticality Safety Analyses

In nuclear criticality safety engineering, calculation methods are one of the methods used to establish the subcritical limits for operations involving fissile material. The American National Standards Institute (ANSI) gives fundamental guidance for establishing these limits in ANSI/ANS-8.1-1998, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors."[iii] In paragraph 4.2.5, the standard states:

> In the absence of directly applicable experimental measurements, the limits may be derived from calculations made by a method shown by comparison with experimental data to be valid in accordance with 4.3.

Section 4.3 of the Standard provides additional guidance on the general procedure for establishing validity. This includes establishment of bias (4.3.1), bias trend (4.3.2), uncertainty (4.3.3), computer dependence (4.3.4), consistency with measurement (4.3.5), and preparing a written validation report (4.3.6).

This criticality validation includes systems consisting of fissile and fissionable material in metallic, solution and other physical forms, as described in summary in this report, and in more detail in the first six volumes of the OECD Handbook. The emphasis of this criticality validation is on comparison of calculated neutron multiplication factors (k_{eff}) with experimental results, and on establishment of bias, bias trends, and uncertainty as a final step. Compiled data for nearly 1200 critical experiments is used as the basis for the calculation models. The calculated results from SCALE 4.4a using the 238-group ENDF/B-V SCALE 4.4a cross-section libraries have been compared with reported results for the benchmark experiments. Comparison of results demonstrates that SCALE 4.4a run on CMODB produces

the same results (within the statistical uncertainty of the Monte Carlo calculations) as reported by the experiments where similar (SCALE, 238-group library) results were published. Subcritical limits can be determined through an analysis of the criticality calculation results. Determination of these limits will be addressed in a separate report. Extension of the validation to other computer platforms will be addressed separately.

1.2 Terminology

The term "model" may be used in two different ways in validation work. Often, as in this report, "model" generally refers to the calculation model, or the collection of input parameters for the numerical simulation in SCALE/KENO of the physical critical experiment. In statistical analyses, the term "model" generally refers to a statistical model, or an equation describing the relationship between parameters considered in the statistical analysis. In this report the intended meaning should be clear from the context, but generally the former meaning is intended in this report.

2 Description of SCALE 4.4a Code Package

The U. S. Nuclear Regulatory Commission (NRC) originally sponsored the Standardized Computer Analyses for Licensing Evaluation (SCALE) code system. The original concept of SCALE was to provide "standardized" sequences where the user had very few analyses options in addition to the geometry model and materials. Input for the control modules has been designed to be free form with extensive use of keyword and engineering-type input requirements. The stand-alone functional modules are more flexible, but they have a more difficult input logic and require the user to manually interface the data sets necessary to run the modules in a stand-alone fashion. As the system has grown in popularity over the years and additional options have been requested, the control modules have been improved to allow sophisticated users additional access to the numerous capabilities within the functional modules. However, the most important feature of the SCALE system remains the capability to simplify the user knowledge and effort required to prepare material mixtures and to perform adequate problem-dependent cross-section processing.

The modules available in Version 0 of SCALE were for Criticality Safety Analysis Sequences (CSAS) that provided automated material and cross-section processing prior to a one-dimensional (1-D) or multidimensional criticality analysis. Since that time the capabilities of the system have been significantly expanded to provide additional CSAS capabilities as well as Shielding Analysis Sequences (SAS) and a Heat Transfer Analysis Sequence (HTAS). At the center of the CSAS and SAS sequences is the library of subroutines referred to as the Material Information Processor or MIPLIB. The purpose of MIPLIB is to allow users to specify problem materials using easily remembered and easily recognizable keyword that are associated with mixtures, elements, and nuclides provided in the Standard Composition Library. MIPLIB also uses other keyword and simple geometry input specifications to prepare input for the modules that perform the problem-dependent cross-section processing: BONAMI, NITAWL-II, and XSDRNPM. A keyword supplied by the user selects the cross-section library from a standard set provided in SCALE or designates the reference to a user-supplied library. Several utility modules from AMPX have been included to provide users with the capability to edit the cross-section data and reformat user-supplied libraries for use in SCALE.

Table 2.1 provides a summary of the major applications of each of the control modules and functional modules currently in the SCALE code system and relevant to criticality safety calculations that are covered in this report. The control modules were designed to provide the system analysis capability originally requested by the NRC staff. The CSAS module (sometimes denoted as the CSAS4 module) is the primary control module designed for the calculation of the neutron multiplication factor of a system. Eight sequences enable general analysis of a 1-D system model or a multidimensional system model, capabilities to search on geometry spacing, and problem-dependent cross-section processing for use in executing stand-alone functional modules. CSAS6 is a new criticality control module to provide automated problem-dependent cross-section processing and criticality calculations via the

new KENO-VI functional module. Neither XSDRNPM nor KENO-VI is covered in this report. The CSAS25 sequence was used for this report.

Table 2.1. Analysis capabilities summary of the SCALE control and functional modules covered in this report

Control Module	Analysis function(s)	Functional modules executed
CSAS25	3-D Monte Carlo calculation of k-eff; Problem-dependent cross-section processing; Multiplication search or spacing	BONAMI NITAWL-II KENO V.a

Functional module	Function
BONAMI	Resonance self-shielding of cross sections with Bondarenko factors
NITAWL-II	Resonance self-shielding of cross sections with resolved resonance data
KENO V.a	Monte Carlo code for calculation of neutron multiplication factors

A 238-energy-group neutron cross-section library based on ENDF/B-V is available for the SCALE system, and was used exclusively in this revision. All the nuclides that are available in ENDF/B-V are in the library. Other available libraries include a 44-group library, was collapsed from the 238-group library, a 218-group ENDF/B-IV library, and a 27-group ENDF/B-IV library, which is the broad-group companion library to the 218-group ENDF/B-IV library. In revision 0, the 44-group and 27-group libraries were also included. The 44-group library made available an ENDF/B-V broad-group companion library in case the 238-group library did not perform well (in terms of computer memory and time) in a production environment at Y-12. The 27-group library allowed "validated" comparisons with previous analyses, using the same library that was previously used for many years. Since revision 0, the computer time and memory performance of the 238-group library has been adequate.

A recent ORNL report assessed the numerical performance of the available libraries[iii]. The recommendation supports using the 238-group library, but the endorsements are somewhat qualified. The report states, "This library is recommended as the best library in SCALE for general-purpose criticality-safety analyses." The report also states "Although any intermediate-energy problems are suspect because of the scarcity of critical experiments, this library performs better than any other library in SCALE." Regarding the weaknesses of the 44-group library, the report states "Because of the 1/E weighting in the 238-group library, this library is not a good general-purpose library." In addition, it states "The 44-group library has all the shortcomings of the 238-group library, as well as not being able to calculate homogeneous thermal, epithermal, and intermediate-energy systems as accurately as the 238-group library." On the other hand, regarding strengths of the 44-group library, the report says "LWR and mixed-oxide lattices are the library's strong point, and it is the recommended SCALE library for these applications." The report suggests that the 238-group library should be considered the general library of choice except perhaps for applications where the 44-group library may perform slightly better, such as ^{235}U LWR (low enriched) and MOX lattices, and for ^{233}U. This may partly explain why the ^{233}U results in this report are slightly worse than for other fissionable materials.

Finally, the ORNL report anticipates development of an improved 238-group library based on ENDF/B-VI, a "refined library with additional groups (partially to facilitate analysis of problems with a dominant intermediate-energy spectrum)," and predicts that "The next version of SCALE will include a continuous-energy cross-section library." The recommendations and future directions suggest a preference for the 238-group library. Therefore, in this revision the 238-group library was used exclusively.

3 Discussion of Criticality Benchmark Database for Validation of CSAS25 from SCALE 4.4a

The United States Department of Energy initiated the Criticality Safety Benchmark Evaluation Project (CSBEP) in October of 1992. The project quickly grew into an international effort, as scientists from other interested countries became involved. The International Criticality Safety Benchmark Evaluation Project (ICSBEP) is now an official activity of the Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA). The wide scale evaluation effort has concluded with the publication of the "International Handbook of Criticality Safety Benchmark Experiments" [i] (OECD Handbook). The seven-volume set of handbooks contains criticality safety benchmark specifications derived from experiments that were performed at various nuclear critical facilities around the world. The benchmark specifications are intended for use by criticality safety engineers to validate the application of calculation techniques, such as SCALE 4.4a, for criticality safety analyses. Example calculations presented in the handbook do not constitute a validation of the codes or cross section data sets by themselves, but use of the information contained in the Handbook can be and has been used to validate SCALE 4.4a by competent nuclear criticality safety persons. The evaluated criticality safety benchmark data are published in the seven-volume OECD Handbook, previously in hard copy form, and recently only on compact disk (CD). Acrobat® Reader is used to access the CD for extraction of experiment descriptions and input files.

For this criticality validation of SCALE 4.4a, fissile material forms include uranium systems, plutonium systems, mixed uranium and plutonium systems, and Uranium-233 systems. The validation comprises a substantial subset of the database used to prepare the first six volumes of the OECD Handbook. Table 3.1 summarizes the evaluated benchmark experiments that are analyzed in this validation. The data from the benchmark experiments represents a sufficiently wide range of fissile and fissionable materials, enrichments, and physical and chemical forms to cover many existing, planned or unforeseen activities for the Y-12 site. These include enriched uranium with ^{235}U only, natural and depleted uranium, intermediate (10-60%) enriched uranium, highly (>60%) enriched uranium, uranium-233, plutonium, and mixed plutonium-uranium systems. Data analyzed from critical experiments in this validation includes systems having fast, intermediate and thermal neutron energy spectra, and they include materials in various physical and chemical forms such as metals, solutions, and oxide compounds.

For many benchmark experiments, critical conditions are tabulated in the OECD Handbook for a number of parametric variables (height, concentration, shape, etc.) Although calculation results for all of these cases are reported, often SCALE 4.4a input details for only some of these cases are actually provided in the OECD Handbook. Input data for the CSAS25 cases are based on information contained in the OECD distribution CD, which is accessed using Acrobat® Reader software. The CD contains the text of the Handbook in the form of Portable Document Format (PDF) files. It also contains a section of selected input file listings. The listings in the two sections do not always correspond, so input files were taken from both parts of the CD, where they differed. In addition, where it was practical, inputs present for only one cross-section set were modified and copied to use with the 238-group cross-section library. Cases were first prepared using the 1998 edition of the CD, and additional cases were taken from the subsequent editions through 2002. Each subsequent revision provides additional experiments and input data. The organization and categorization of the experiments and data on the CD also changes.

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Reviews were performed of the input preparation in a graded approach. For models based on sample inputs, reviews generally assume the models are adequate unless reasons are found to think otherwise, at the discretion of the reviewer. Models prepared from scratch, based on experiment descriptions, are given more scrutiny. Mentors review models submitted as part of the Nuclear Criticality Safety (NCS) qualifications program.

A total of 1217 cases were extracted from the CD or created from experiment descriptions, and are included in this revision. Table 3.1 shows the number of cases that were obtained in various categories. A copy of the input data for the validation cases is maintained on the CMODB workstation.

Due to the large number of benchmark experiment cases included in this revision, the OECD Handbook and associated DICE database search software are considered the best source for obtaining summary and detailed descriptive information for the benchmark experiments. Appendix A of this report gives a comparison of available experiments that could have been modeled, versus experiments that were modeled and included in validations. This list will be useful for determining what models to create for future inclusion in the validation, and for very abbreviated descriptions (titles).

The OECD report contains the following admonishment: "Sample input listings are not intended to be used directly for validation efforts and should be verified by the user. Since it is not practical to describe in detail the code input used to model each benchmark critical experiment, computer input listings are given for typical reported calculations of accepted benchmark configurations. From these listings, a user can identify which options were used to obtain the reported results. This is the sole purpose for inclusion of the input listings. It is the responsibility of the user to ensure that use of these listings for any other purpose is consistent with proper criticality safety practices." In performing this validation effort, the "universe" of experiments was the experiments available on the CD. No additional, independent selection of applicable experiments was performed. Advantage was taken of the available sample input listings to the maximum extent feasible. Some additional models were created based on parameter changes to the sample models, and some models were created from scratch based on the experiment descriptions, particularly as part of the Y-12 NCS qualifications program.

Reviews were performed of the input preparation in a graded approach. For models based on sample inputs, reviews generally assume the models are adequate unless reasons are found to think otherwise, at the discretion of the reviewer. Models prepared from scratch, based on experiment descriptions, are given more scrutiny. Mentors review models submitted as part of the NCS qualifications program.

It is recognized that there were experiments, which were not included because input models were not readily available, that would be applicable for Y-12. Also, some experiments were included that are probably not currently very directly applicable to Y-12 work. This is not a concern as long as these experiments do not have a large difference in bias compared with the other experiments in the category. The additional experiments provide confidence in the code's ability to calculate over a broader area of applicability than the minimum necessary for currently planned Y-12 applications.

Table 3.1 Number of Input Cases Extracted from the OECD Compact Disk

	Fissile Material Category (OECD Benchmark Volume)							
	II	III	IV		I	VI	V	
Material / Energy	High Enriched Uranium	Intermediate Enriched Uranium	Low Enriched Uranium	Subtotal Uranium-235 fissile	Plutonium	Mixed Plutonium-Uranium	Uranium-233	Total
Metal/Fast	106	16	0	122	62	33	10	227
Metal/Intermediate	4	0	0	4	0	0	0	4
Metal/Thermal	31	0	13	44	0	0	0	44
Metal/Mixed	3	0	0	3	0	0	0	3
Compound/Fast	0	0	0	0	0	0	0	0
Compound/Intermediate	12	4 *	0	16	1	0	0	17
Compound/Thermal	24	31	99	154	0	92	0	246
Compound/Mixed	9	0	0	9	9	0	0	18
Solution/Intermediate	0	0	0	0	0	0	33	33
Solution/Thermal	271	0	16	287	198	32	97	614
Solution/Mixed	0	0	0	0	0	0	0	0
Misc./Thermal	0	0	0	0	0	11	0	11
Total	460	51	128	639	270	168	140	1217
		* Note: Two of these intermediate energy cases should have been categorized as fast or thermal						

4 Tabulated Results of CSAS25 from SCALE 4.4a Criticality Calculations

Input data for the CSAS25 cases are based on information contained in the OECD distribution CD, as described in Section 3. Calculations were performed for the 238-group cross-section library.

The input cases were altered as little as possible unless there was an error, but the parameters were generally altered to include:

Parm=size=4000000 and

gen=500 npg=2000 nsk=100 tba=10 nub=yes

This results in 1,000,000 total neutron histories per case, skipping the first 100 generations, allows up to 10 minutes per batch, and causes the run output to include values for "Average Fission Group" (AFG) and "Energy of Average Lethargy Causing Fission" (EALCF). Using "nub=yes" is no longer necessary because it is now a default setting, but this is a carryover from previous versions which had 'hub=no" as default.

For each CSAS25 case, Tables 4.1-4.6 list the following results: the mean of the final k_{eff} (k_cal) after 800,000 histories, and the standard deviation of that mean; the mean of the AFG, the mean of the EALCF, and the associated standard deviations. In addition, the expected, or experimental, k-effective (k_exp) and associated error estimate from the OECD benchmark handbook is also provided. The values of AFG and EALCF are included as potential regression variables because previously there was an expectation that the bias between experiment and Monte Carlo calculation might be correlated with these parameters. All results in this report are 238-group results.

Table 4.1 Results for Plutonium Systems (Volume 1) with CSAS25 from SCALE 4.4a and the 238-group Library on the J-5600 (CMODB) Workstation

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
1	CI001	./puci.001/puci001	2.898	1.85E-05	87.19	0.015	3.09E+02	3.11E-01	0.999	0.0002	1	0.011	-0.001	0.999
2	CM001	./pucm.001/pucm001-01	3.107	2.47E-04	24.05	0.018	9.58E+05	1.59E+03	1.024	0.0011	0.9986	0.0041	0.026	1.026
3		./pucm.001/pucm001-02	2.969	1.28E-04	80.68	0.046	1.73E+03	6.90E+00	1.022	0.0012	1	0.0068	0.022	1.022
4		./pucm.001/pucm001-03	2.919	5.75E-05	131.93	0.041	3.25E+01	9.49E-02	1.016	0.0011	0.999	0.0067	0.017	1.017
5		./pucm.001/pucm001-04	2.921	6.21E-05	128.78	0.043	3.96E+01	1.25E-01	0.988	0.0011	1	0.0066	-0.012	0.988
6		./pucm.001/pucm001-05	2.902	2.21E-05	174.9	0.03	1.54E+00	3.33E-03	1.01	0.0015	0.9989	0.0072	0.011	1.011
7	CM002	./pucm.002/pucm002-01	3.026	2.14E-04	80.85	0.087	4.97E+03	3.78E+01	1.032	0.001	0.999	0.0046	0.033	1.033
8		./pucm.002/pucm002-10	2.909	4.61E-05	160.17	0.047	4.17E+00	1.37E-02	1.032	0.001	1	0.0073	0.032	1.032
9		./pucm.002/pucm002-22	2.912	5.04E-05	153.74	0.051	6.44E+00	2.35E-02	1.015	0.0013	0.9988	0.0055	0.016	1.016
10		./pucm.002/pucm002-23	2.9	1.93E-05	185.39	0.028	6.89E-01	1.51E-03	1.009	0.001	1	0.0068	0.009	1.009
11	MF001	./pumf.001/case_1	3.137	2.85E-04	21.42	0.013	1.24E+06	1.47E+03	0.995	0.0014	1	0.002	-0.005	0.995
12	MF002	./pumf.002/case_1	3.134	2.72E-04	21.23	0.012	1.26E+06	1.44E+03	0.995	0.0012	1	0.002	-0.005	0.995
13	MF003	./pumf.003/case_101	3.135	2.84E-04	21.44	0.013	1.24E+06	1.55E+03	0.993	0.001	1	0.003	-0.007	0.993
14		./pumf.003/case_102	3.124	2.89E-04	27.72	0.038	6.91E+05	2.38E+03	0.992	0.001	1	0.003	-0.008	0.992
15		./pumf.003/case_103	3.135	2.69E-04	21.43	0.013	1.24E+06	1.45E+03	0.986	0.0011	1	0.003	-0.014	0.986
16		./pumf.003/case_104	3.122	2.77E-04	28.79	0.041	6.25E+05	2.32E+03	0.995	0.001	1	0.003	-0.005	0.995
17		./pumf.003/case_105	3.136	2.90E-04	21.42	0.013	1.24E+06	1.48E+03	0.993	0.0011	1	0.003	-0.007	0.993
18	MF004	./pumf.004/case_207	3.135	2.83E-04	21.88	0.016	1.19E+06	1.69E+03	0.99	0.001	1	0.003	-0.01	0.99
19		./pumf.004/case_208	3.136	2.83E-04	22.26	0.019	1.15E+06	1.95E+03	0.99	0.0011	1	0.003	-0.01	0.99
20		./pumf.004/case_209	3.135	2.74E-04	22.27	0.019	1.15E+06	1.99E+03	0.99	0.0012	1	0.003	-0.01	0.99
21		./pumf.004/case_210	3.135	2.70E-04	22.3	0.018	1.15E+06	1.88E+03	0.988	0.0011	1	0.003	-0.012	0.988

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
22		./pumf.004/case_211	3.135	2.80E-04	22.29	0.019	1.15E+06	1.97E+03	0.99	0.0009	1	0.003	-0.01	0.99
23		./pumf.004/case_212	3.136	2.81E-04	22.26	0.018	1.15E+06	1.95E+03	0.989	0.0013	1	0.003	-0.011	0.989
24		./pumf.004/case_213	3.136	2.86E-04	21.61	0.014	1.22E+06	1.64E+03	0.988	0.0011	1	0.003	-0.012	0.988
25		./pumf.004/case_214	3.137	2.97E-04	21.73	0.016	1.21E+06	1.73E+03	0.989	0.0011	1	0.003	-0.011	0.989
26		./pumf.004/case_215	3.136	2.73E-04	21.48	0.013	1.24E+06	1.50E+03	0.988	0.0011	1	0.003	-0.012	0.988
27	MF005	./pumf.005/case_1	3.103	2.54E-04	23.94	0.014	9.83E+05	1.26E+03	1.005	0.0011	1	0.0013	0.005	1.005
28	MF006	./pumf.006/case_001	2.972	5.19E-04	22.61	0.015	1.10E+06	1.55E+03	0.999	0.0013	1	0.003	-0.001	0.999
29	MF008	./pumf.008/case_1	3.065	7.86E-04	23.36	0.014	1.04E+06	1.39E+03	1.001	0.0009	1	0.0006	0.001	1.001
30	MF009	./pumf.009/case_1	3.122	0.000267	22.35	0.013	1.14E+06	1.39E+03	0.993	0.001	1	0.0027	-0.007	0.993
31	MF010	./pumf.010/case_1	3.065	2.97E-04	21.97	0.012	1.19E+06	1.40E+03	0.997	0.0011	1	0.0018	-0.003	0.997
32	MF011	./pumf.011/case_1	3.087	2.80E-04	50.72	0.073	8.34E+04	5.45E+02	0.995	0.0011	1	0.001	-0.005	0.995
33	MF012	./pumf.012/case_1	2.971	0.000633	23.65	0.019	9.78E+05	1.67E+03	1.004	0.001	1.0009	0.0021	0.004	1.004
34	MF013	./pumf.013/case_1	3.079	0.000225	26.15	0.015	7.75E+05	1.15E+03	1.004	0.0012	1.0034	0.0023	0	1
35	MF014	./pumf.014/case_1	3.081	0.000247	26	0.015	7.83E+05	1.22E+03	1.016	0.001	1.0037	0.0031	0.012	1.012
36	MF015	./pumf.015/case_1	3.094	0.000245	24.62	0.015	9.09E+05	1.34E+03	1.018	0.0011	1.0041	0.0026	0.014	1.014
37	MF016	./pumf.016/case_001	3.054	2.50E-04	73.29	0.09	1.14E+04	8.93E+01	1.011	0.001	0.9974	0.0042	0.013	1.013
38		./pumf.016/case_002	3.052	2.33E-04	76.69	0.082	8.57E+03	6.16E+01	1	0.001	1	0.0038	0	1
39		./pumf.016/case_003	3.051	2.42E-04	77.25	0.083	8.18E+03	5.88E+01	0.998	0.0013	1	0.0033	-0.002	0.998
40		./pumf.016/case_004	3.051	2.32E-04	77.41	0.082	8.08E+03	5.67E+01	0.998	0.001	1	0.003	-0.002	0.998
41		./pumf.016/case_005	3.051	2.49E-04	77.62	0.082	7.93E+03	5.72E+01	0.997	0.001	1	0.0034	-0.003	0.997
42		./pumf.016/case_006	3.051	2.62E-04	77.79	0.087	7.82E+03	5.94E+01	1.001	0.001	1	0.0032	0.001	1.001
43	MF017	./pumf.017/case_201	3.117	3.10E-04	25.53	0.026	7.82E+05	2.08E+03	0.988	0.0012	1	0.003	-0.012	0.988
44		./pumf.017/case_202	3.102	2.79E-04	32.16	0.042	4.04E+05	1.65E+03	0.991	0.0012	1	0.003	-0.009	0.991
45		./pumf.017/case_203	3.093	2.84E-04	38.28	0.051	2.31E+05	1.12E+03	0.996	0.0011	1	0.003	-0.004	0.996
46		./pumf.017/case_204	3.101	2.77E-04	30.43	0.04	4.57E+05	1.83E+03	0.991	0.0011	1	0.003	-0.009	0.991
47		./pumf.017/case_205	3.075	2.70E-04	47.5	0.062	9.48E+04	5.46E+02	0.999	0.0011	1	0.003	-0.001	0.999
48	MF018	./pumf.018/case_1	3.103	2.54E-04	24.45	0.015	8.97E+05	1.44E+03	1	0.0011	1	0.003	0	1

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
49	MF022	./pumf.022/pumf022	3.135	2.77E-04	21.56	0.013	1.23E+06	1.51E+03	0.992	0.001	1	0.0021	-0.008	0.992
50	MF023	./pumf.023/pumf023	3.123	2.73E-04	22.36	0.013	1.14E+06	1.40E+03	0.995	0.001	1	0.002	-0.005	0.995
51	MF024	./pumf.024/pumf024	3.115	2.66E-04	27.69	0.034	6.32E+05	2.14E+03	0.997	0.001	1	0.002	-0.003	0.997
52	MF025	./pumf.025/pumf025	3.126	2.60E-04	22.03	0.013	1.17E+06	1.38E+03	0.997	0.0011	1	0.002	-0.003	0.997
53	MF026	./pumf.026/pumf026	3.109	2.58E-04	23.29	0.013	1.04E+06	1.33E+03	1.017	0.0012	1	0.0024	0.017	1.017
54	MF027	./pumf.027/pumf027	3.079	2.72E-04	51.82	0.071	7.18E+04	4.60E+02	1	0.0011	1	0.0022	0	1
55	MF028	./pumf.028/pumf028	3.105	2.42E-04	23.5	0.014	1.02E+06	1.33E+03	1.018	0.0013	1	0.0022	0.018	1.018
56	MF029	./pumf.029/pumf029	3.136	2.77E-04	21.37	0.013	1.25E+06	1.51E+03	0.992	0.0012	1	0.002	-0.008	0.992
57	MF030	./pumf.030/pumf030	3.123	2.62E-04	22.3	0.013	1.14E+06	1.41E+03	0.997	0.001	1	0.0021	-0.003	0.997
58	MF031	./pumf.031/pumf031	3.096	2.79E-04	41.13	0.062	1.85E+05	1.03E+03	1	0.0012	1	0.0021	0	1
59	MF032	./pumf.032/pumf032	3.121	2.55E-04	22.21	0.013	1.15E+06	1.35E+03	1.003	0.0012	1	0.002	0.003	1.003
60	MF033	./pumf.033/zppr-21a	3.006	1.32E-04	31.85	0.02	4.01E+05	8.67E+02	1.008	0.0008	0.9967	0.0026	0.011	1.011
61	MF035	./pumf.035/pumf035	3.126	2.64E-04	22.02	0.014	1.17E+06	1.49E+03	1.006	0.0011	1	0.0016	0.006	1.006
62	MF036	./pumf.036/pumf036	3.111	2.71E-04	27.47	0.032	6.13E+05	2.06E+03	1.003	0.0012	1	0.0031	0.003	1.003
63	MF037	./pumf.037/pumf037-01	3.087	2.73E-04	44.02	0.064	1.46E+05	8.45E+02	1	0.0011	1	0.0044	0	1
64		./pumf.037/pumf037-05	3.072	2.64E-04	55.52	0.078	5.19E+04	3.59E+02	0.997	0.001	1	0.0037	-0.003	0.997
65		./pumf.037/pumf037-07	3.066	2.57E-04	60.61	0.075	3.31E+04	2.22E+02	0.998	0.0011	1	0.0038	-0.002	0.998
66		./pumf.037/pumf037-10	3.063	2.60E-04	63.65	0.075	2.59E+04	1.70E+02	0.998	0.0011	1	0.0034	-0.002	0.998
67		./pumf.037/pumf037-12	3.062	2.50E-04	64.73	0.076	2.35E+04	1.58E+02	0.999	0.0011	1	0.004	-0.001	0.999
68		./pumf.037/pumf037-15	3.06	2.58E-04	67.65	0.086	1.85E+04	1.39E+02	0.998	0.0012	1	0.0033	-0.002	0.998
69		./pumf.037/pumf037-16	3.065	2.68E-04	62.77	0.079	2.87E+04	1.99E+02	1.001	0.0011	1	0.0039	0.001	1.001
70	MF039	./pumf.039/pumf039	3.124	2.66E-04	22.2	0.013	1.16E+06	1.43E+03	0.983	0.001	1	0.0022	-0.017	0.983
71	MF040	./pumf.040/pumf040	3.122	2.77E-04	22.38	0.013	1.14E+06	1.42E+03	0.991	0.001	1	0.0038	-0.009	0.991
72	MF041	./pumf.041/pumf041	2.99	5.98E-04	22.13	0.017	1.14E+06	1.76E+03	1.005	0.0012	1	0.0016	0.005	1.005
73	ST001	./pust.001/case_1_t9	2.891	5.43E-06	212.49	0.008	8.79E-02	8.61E-05	1.007	0.001	1	0.005	0.007	1.007
74		./pust.001/case_2_t9	2.891	6.15E-06	209.97	0.009	1.11E-01	1.15E-04	1.01	0.0011	1	0.005	0.01	1.01
75		./pust.001/case_3_t9	2.891	6.87E-06	207.76	0.011	1.35E-01	1.64E-04	1.012	0.0012	1	0.005	0.012	1.012

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	k_calc sigma	k_calc Pu	k_calc sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
76		./pust.001/case_4_t9	2.891	7.76E-06	206.42	0.012	1.51E-01	1.90E-04	1.004	0.0012	1	0.005	0.004	1.004
77		./pust.001/case_5_t9	2.891	7.49E-06	205.78	0.012	1.59E-01	2.04E-04	1.01	0.0011	1	0.005	0.01	1.01
78		./pust.001/case_6_t9	2.893	1.19E-05	195.79	0.018	3.47E-01	5.40E-04	1.008	0.0011	1	0.005	0.008	1.008
79	ST002	./pust.002/case_1	2.891	4.00E-06	214.68	0.006	7.13E-02	5.56E-05	1.007	0.001	1	0.0047	0.007	1.007
80		./pust.002/case_2	2.891	4.30E-06	214.46	0.006	7.29E-02	5.83E-05	1.008	0.0012	1	0.0047	0.008	1.008
81		./pust.002/case_3	2.891	4.48E-06	213.8	0.007	7.79E-02	6.68E-05	1.007	0.001	1	0.0047	0.007	1.007
82		./pust.002/case_4	2.891	4.54E-06	213.36	0.007	8.14E-02	7.04E-05	1.01	0.001	1	0.0047	0.01	1.01
83		./pust.002/case_5	2.891	4.84E-06	212.9	0.007	8.51E-02	8.00E-05	1.013	0.0014	1	0.0047	0.013	1.013
84		./pust.002/case_6	2.891	5.19E-06	211.97	0.008	9.28E-02	8.81E-05	1.01	0.0012	1	0.0047	0.01	1.01
85		./pust.002/case_7	2.891	5.98E-06	211.14	0.009	1.00E-01	1.05E-04	1.01	0.0013	1	0.0047	0.01	1.01
86	ST003	./pust.003/case_1	2.891	3.17E-06	216.63	0.005	5.83E-02	3.73E-05	1.007	0.001	1	0.0047	0.007	1.007
87		./pust.003/case_2	2.891	3.48E-06	216.45	0.005	5.95E-02	4.00E-05	1.009	0.0012	1	0.0047	0.009	1.009
88		./pust.003/case_3	2.891	3.68E-06	216.07	0.005	6.18E-02	4.40E-05	1.01	0.0011	1	0.0047	0.01	1.01
89		./pust.003/case_4	2.891	3.74E-06	215.93	0.005	6.28E-02	4.50E-05	1.007	0.001	1	0.0047	0.007	1.007
90		./pust.003/case_5	2.891	3.91E-06	215.53	0.006	6.55E-02	4.99E-05	1.008	0.0012	1	0.0047	0.008	1.008
91		./pust.003/case_6	2.891	4.14E-06	214.96	0.006	6.95E-02	5.35E-05	1.009	0.0011	1	0.0047	0.009	1.009
92		./pust.003/case_7	2.891	3.66E-06	216.49	0.005	5.91E-02	4.11E-05	1.01	0.0011	1	0.0047	0.01	1.01
93		./pust.003/case_8	2.891	3.52E-06	216.32	0.005	6.02E-02	3.95E-05	1.008	0.0011	1	0.0047	0.008	1.008
94	ST004	./pust.004/case_1	2.891	2.90E-06	217.47	0.004	5.34E-02	3.03E-05	1.007	0.0011	1	0.0047	0.007	1.007
95		./pust.004/case_10	2.891	3.61E-06	215.88	0.005	6.32E-02	4.30E-05	1.007	0.001	1	0.0047	0.007	1.007
96		./pust.004/case_11	2.891	3.90E-06	215.1	0.006	6.85E-02	5.14E-05	1.004	0.001	1	0.0047	0.004	1.004
97		./pust.004/case_12	2.891	3.09E-06	217.04	0.004	5.58E-02	3.42E-05	1.009	0.0013	1	0.0047	0.009	1.009
98		./pust.004/case_13	2.891	3.01E-06	217.07	0.004	5.56E-02	3.32E-05	1.003	0.001	1	0.0047	0.003	1.003
99		./pust.004/case_2	2.891	2.91E-06	217.4	0.004	5.37E-02	2.92E-05	1.004	0.001	1	0.0047	0.004	1.004
100		./pust.004/case_3	2.891	3.11E-06	217.24	0.004	5.47E-02	3.19E-05	1.007	0.0009	1	0.0047	0.007	1.007
101		./pust.004/case_4	2.891	3.14E-06	217.04	0.004	5.59E-02	3.47E-05	1.002	0.0013	1	0.0047	0.002	1.002
102		./pust.004/case_5	2.891	2.83E-06	217.26	0.004	5.46E-02	3.07E-05	1.005	0.001	1	0.0047	0.005	1.005

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
103		./pust.004/case_6	2.891	3.02E-06	217.2	0.004	5.49E-02	3.25E-05	1.005	0.0011	1	0.0047	0.005	1.005
104		./pust.004/case_7	2.891	3.12E-06	217.04	0.004	5.58E-02	3.29E-05	1.012	0.0011	1	0.0047	0.012	1.012
105		./pust.004/case_8	2.891	3.16E-06	216.91	0.004	5.66E-02	3.49E-05	1.004	0.001	1	0.0047	0.004	1.004
106		./pust.004/case_9	2.891	3.37E-06	216.59	0.004	5.86E-02	3.62E-05	1.006	0.001	1	0.0047	0.006	1.006
107	ST005	./pust.005/case_1	2.891	3.18E-06	217.07	0.004	5.56E-02	3.38E-05	1.007	0.0009	1	0.0047	0.007	1.007
108		./pust.005/case_2	2.891	3.35E-06	216.91	0.004	5.66E-02	3.66E-05	1.008	0.0011	1	0.0047	0.008	1.008
109		./pust.005/case_3	2.891	3.18E-06	216.74	0.004	5.76E-02	3.60E-05	1.008	0.0011	1	0.0047	0.008	1.008
110		./pust.005/case_4	2.891	3.55E-06	216.35	0.005	6.01E-02	3.95E-05	1.009	0.0011	1	0.0047	0.009	1.009
111		./pust.005/case_5	2.891	3.66E-06	215.91	0.005	6.30E-02	4.45E-05	1.012	0.001	1	0.0047	0.012	1.012
112		./pust.005/case_6	2.891	3.84E-06	215.45	0.005	6.61E-02	4.92E-05	1.011	0.0011	1	0.0047	0.011	1.011
113		./pust.005/case_7	2.891	3.97E-06	215	0.005	6.91E-02	5.10E-05	1.008	0.001	1	0.0047	0.008	1.008
114		./pust.005/case_8	2.891	3.13E-06	216.9	0.004	5.66E-02	3.45E-05	1.002	0.0009	1	0.0047	0.002	1.002
115		./pust.005/case_9	2.891	3.30E-06	216.68	0.004	5.79E-02	3.56E-05	1.006	0.0011	1	0.0047	0.006	1.006
116	ST006	./pust.006/case_1	2.891	2.69E-06	217.62	0.004	5.25E-02	2.83E-05	1.005	0.001	1	0.0035	0.005	1.005
117		./pust.006/case_2	2.891	2.78E-06	217.46	0.004	5.34E-02	2.93E-05	1.007	0.001	1	0.0035	0.007	1.007
118		./pust.006/case_3	2.891	3.06E-06	217.15	0.004	5.52E-02	3.30E-05	1.008	0.0011	1	0.0035	0.008	1.008
119	ST007	./pust.007/case_10	2.891	6.04E-06	210.45	0.009	1.06E-01	1.14E-04	1.002	0.0011	1	0.0047	0.002	1.002
120		./pust.007/case_2	2.892	1.10E-05	198.9	0.018	2.75E-01	4.45E-04	1.009	0.001	1	0.0047	0.009	1.009
121		./pust.007/case_3	2.892	1.07E-05	199.57	0.017	2.61E-01	4.01E-04	1.003	0.0012	1	0.0047	0.003	1.003
122		./pust.007/case_5	2.891	6.05E-06	209.87	0.01	1.12E-01	1.22E-04	1.011	0.0012	1	0.0047	0.011	1.011
123		./pust.007/case_6	2.891	6.05E-06	209.68	0.009	1.14E-01	1.18E-04	1.005	0.0011	1	0.0047	0.005	1.005
124		./pust.007/case_7	2.891	6.26E-06	209.81	0.01	1.12E-01	1.27E-04	1.009	0.001	1	0.0047	0.009	1.009
125		./pust.007/case_8	2.891	6.18E-06	209.6	0.01	1.15E-01	1.30E-04	1	0.001	1	0.0047	0	1
126		./pust.007/case_9	2.891	6.19E-06	209.62	0.011	1.14E-01	1.33E-04	0.999	0.0013	1	0.0047	-0.001	0.999
127	ST009	./pust.009/case_1	2.892	1.65E-06	219.73	0.002	4.11E-02	1.31E-05	1.02	0.0006	1	0.0047	0.02	1.02
128		./pust.009/case_2	2.892	1.63E-06	219.82	0.002	4.07E-02	1.31E-05	1.025	0.0007	1	0.0047	0.025	1.025
129		./pust.009/case_3	2.892	1.63E-06	219.83	0.002	4.06E-02	1.30E-05	1.023	0.0006	1	0.0047	0.023	1.023

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
130	ST010	./pust.010/case_1_11	2.891	4.50E-06	214.13	0.006	7.55E-02	6.19E-05	1.017	0.001	1	0.0048	0.017	1.017
131		./pust.010/case_1_12	2.891	3.94E-06	214.89	0.006	6.99E-02	5.50E-05	1.013	0.001	1	0.0048	0.013	1.013
132		./pust.010/case_1_9	2.891	5.67E-06	210.08	0.009	1.11E-01	1.14E-04	1.02	0.001	1	0.0048	0.02	1.02
133		./pust.010/case_2_11	2.891	3.90E-06	214.88	0.006	7.01E-02	5.42E-05	1.012	0.0011	1	0.0048	0.012	1.012
134		./pust.010/case_2_12	2.891	3.74E-06	215.53	0.005	6.55E-02	4.74E-05	1.014	0.001	1	0.0048	0.014	1.014
135		./pust.010/case_2_9	2.891	4.96E-06	212.37	0.008	8.94E-02	8.24E-05	1.017	0.0009	1	0.0048	0.017	1.017
136		./pust.010/case_3_11	2.891	4.09E-06	215.03	0.006	6.89E-02	5.30E-05	1.013	0.0011	1	0.0048	0.013	1.013
137		./pust.010/case_3_12	2.891	3.26E-06	216.26	0.005	6.07E-02	3.92E-05	1.021	0.0012	1	0.0048	0.021	1.021
138		./pust.010/case_3_9	2.891	4.36E-06	214.29	0.006	7.42E-02	5.93E-05	1.011	0.0012	1	0.0048	0.011	1.011
139		./pust.010/case_4_11	2.891	3.95E-06	215.37	0.006	6.66E-02	5.13E-05	1.007	0.001	1	0.0048	0.007	1.007
140		./pust.010/case_4_12	2.891	3.23E-06	216.85	0.004	5.70E-02	3.50E-05	1.013	0.0012	1	0.0048	0.013	1.013
141		./pust.010/case_5_11	2.891	3.84E-06	215.74	0.005	6.41E-02	4.50E-05	1.008	0.001	1	0.0048	0.008	1.008
142		./pust.010/case_6_11	2.891	4.47E-06	213.34	0.007	8.14E-02	6.81E-05	1.017	0.0013	1	0.0048	0.017	1.017
143		./pust.010/case_7_11	2.891	4.35E-06	214.8	0.006	7.05E-02	5.55E-05	1.006	0.001	1	0.0048	0.006	1.006
144	ST011	./pust.011/case_1_16	2.891	3.35E-06	215.82	0.005	6.35E-02	4.27E-05	1.014	0.0011	1	0.0052	0.014	1.014
145		./pust.011/case_1_18	2.891	2.74E-06	217.68	0.004	5.20E-02	2.81E-05	1	0.0012	1	0.0052	0	1
146		./pust.011/case_2_16	2.891	3.38E-06	215.64	0.005	6.47E-02	4.31E-05	1.021	0.0013	1	0.0052	0.021	1.021
147		./pust.011/case_2_18	2.891	2.81E-06	217.52	0.004	5.29E-02	3.00E-05	1.007	0.0011	1	0.0052	0.007	1.007
148		./pust.011/case_3_16	2.891	3.77E-06	215.29	0.005	6.71E-02	4.76E-05	1.023	0.0011	1	0.0052	0.023	1.023
149		./pust.011/case_3_18	2.891	2.69E-06	217.53	0.004	5.29E-02	2.88E-05	1.004	0.0013	1	0.0052	0.004	1.004
150		./pust.011/case_4_16	2.891	3.72E-06	215.2	0.005	6.77E-02	4.86E-05	1.015	0.0013	1	0.0052	0.015	1.015
151		./pust.011/case_4_18	2.891	2.96E-06	217.3	0.004	5.42E-02	3.10E-05	0.998	0.001	1	0.0052	-0.002	0.998
152		./pust.011/case_5_16	2.891	4.06E-06	214.16	0.006	7.53E-02	5.99E-05	1.009	0.0013	1	0.0052	0.009	1.009
153		./pust.011/case_5_18	2.891	2.94E-06	217.08	0.004	5.56E-02	3.29E-05	1.01	0.0011	1	0.0052	0.01	1.01
154		./pust.011/case_6_18	2.891	3.23E-06	216.47	0.004	5.94E-02	3.76E-05	1.006	0.0011	1	0.0052	0.006	1.006
155		./pust.011/case_7_18	2.891	2.82E-06	217.34	0.004	5.40E-02	2.94E-05	1.005	0.0011	1	0.0052	0.005	1.005
156	ST014	./pust.014/case_1	2.891	7.18E-06	205.46	0.012	1.68E-01	2.02E-04	1.007	0.0012	0.998	0.0032	0.009	1.009

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
157		./pust.014/case_10	2.891	7.28E-06	205.51	0.011	1.67E-01	2.01E-04	1.007	0.0011	0.998	0.0032	0.009	1.009
158		./pust.014/case_11	2.891	7.35E-06	205.51	0.011	1.67E-01	1.99E-04	1.006	0.0012	0.998	0.0032	0.008	1.008
159		./pust.014/case_12	2.891	6.96E-06	205.54	0.011	1.67E-01	1.98E-04	1.005	0.0011	0.998	0.0032	0.007	1.007
160		./pust.014/case_13	2.891	7.26E-06	205.41	0.011	1.68E-01	1.99E-04	1.007	0.0013	0.998	0.0043	0.009	1.009
161		./pust.014/case_14	2.891	6.69E-06	205.45	0.011	1.68E-01	1.99E-04	1.007	0.0012	0.998	0.0043	0.009	1.009
162		./pust.014/case_15	2.891	7.11E-06	205.52	0.012	1.67E-01	2.06E-04	1.006	0.0014	0.998	0.0043	0.008	1.008
163		./pust.014/case_16	2.891	7.10E-06	205.5	0.011	1.67E-01	2.00E-04	1.004	0.0011	0.998	0.0043	0.006	1.006
164		./pust.014/case_17	2.891	7.36E-06	205.5	0.012	1.67E-01	2.03E-04	1.006	0.0012	0.998	0.0043	0.008	1.008
165		./pust.014/case_18	2.891	7.51E-06	205.44	0.011	1.68E-01	1.99E-04	1.01	0.0011	0.998	0.0043	0.012	1.012
166		./pust.014/case_19	2.891	7.47E-06	205.46	0.011	1.68E-01	2.01E-04	1.006	0.0012	0.998	0.0043	0.008	1.008
167		./pust.014/case_2	2.891	7.11E-06	205.49	0.012	1.67E-01	2.09E-04	1.005	0.0011	0.998	0.0032	0.007	1.007
168		./pust.014/case_20	2.891	7.06E-06	205.48	0.011	1.67E-01	1.97E-04	1.004	0.0012	0.998	0.0043	0.006	1.006
169		./pust.014/case_21	2.891	7.22E-06	205.52	0.012	1.67E-01	2.04E-04	1.006	0.0012	0.998	0.0043	0.008	1.008
170		./pust.014/case_22	2.891	7.67E-06	205.53	0.011	1.67E-01	1.96E-04	1.006	0.0013	0.998	0.0043	0.008	1.008
171		./pust.014/case_23	2.891	7.06E-06	205.51	0.012	1.67E-01	1.97E-04	1.005	0.0013	0.998	0.0043	0.007	1.007
172		./pust.014/case_24	2.891	7.32E-06	205.4	0.011	1.69E-01	1.85E-04	1.008	0.0013	0.998	0.0043	0.01	1.01
173		./pust.014/case_25	2.891	6.88E-06	205.44	0.011	1.68E-01	1.88E-04	1.009	0.001	0.998	0.0043	0.011	1.011
174		./pust.014/case_26	2.891	6.95E-06	205.47	0.012	1.68E-01	2.05E-04	1.004	0.0012	0.998	0.0043	0.006	1.006
175		./pust.014/case_27	2.891	7.05E-06	205.5	0.012	1.67E-01	2.05E-04	1.004	0.0013	0.998	0.0043	0.006	1.006
176		./pust.014/case_28	2.891	7.37E-06	205.53	0.011	1.67E-01	1.94E-04	1.004	0.0012	0.998	0.0043	0.006	1.006
177		./pust.014/case_29	2.891	7.29E-06	205.53	0.012	1.67E-01	1.99E-04	1.007	0.0014	0.998	0.0043	0.009	1.009
178		./pust.014/case_3	2.891	7.16E-06	205.52	0.012	1.67E-01	2.04E-04	1.008	0.0012	0.998	0.0032	0.01	1.01
179		./pust.014/case_30	2.891	7.55E-06	205.42	0.011	1.68E-01	2.00E-04	1.004	0.0015	0.998	0.0043	0.006	1.006
180		./pust.014/case_31	2.891	7.42E-06	205.42	0.012	1.68E-01	2.14E-04	1.003	0.0014	0.998	0.0043	0.005	1.005
181		./pust.014/case_32	2.891	7.59E-06	205.45	0.012	1.68E-01	1.94E-04	1.005	0.0012	0.998	0.0043	0.007	1.007
182		./pust.014/case_33	2.891	7.40E-06	205.47	0.011	1.67E-01	1.94E-04	1.005	0.0012	0.998	0.0043	0.007	1.007
183		./pust.014/case_34	2.891	7.08E-06	205.48	0.012	1.67E-01	2.06E-04	1.005	0.0012	0.998	0.0043	0.007	1.007

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	k_calc sigma	k_calc Pu	k_calc sigma	Benchmark k-eff	Benchmark Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
184		./pust.014/case_4	2.891	7.51E-06	205.52	0.012	1.67E-01	2.11E-04	1.008	0.0013	0.998	0.0032	0.01	1.01
185		./pust.014/case_5	2.891	7.12E-06	205.53	0.012	1.67E-01	1.99E-04	1.008	0.0012	0.998	0.0032	0.01	1.01
186		./pust.014/case_6	2.891	7.27E-06	205.53	0.012	1.67E-01	2.02E-04	1.006	0.0014	0.998	0.0032	0.008	1.008
187		./pust.014/case_7	2.891	7.73E-06	205.45	0.011	1.68E-01	1.99E-04	1.007	0.0013	0.998	0.0032	0.009	1.009
188		./pust.014/case_8	2.891	7.55E-06	205.46	0.012	1.68E-01	2.06E-04	1.006	0.0014	0.998	0.0032	0.008	1.008
189		./pust.014/case_9	2.891	6.91E-06	205.49	0.012	1.67E-01	1.99E-04	1.006	0.0012	0.998	0.0032	0.008	1.008
190	ST015	./pust.015/case_1	2.891	8.54E-06	201.28	0.013	2.37E-01	3.04E-04	1.008	0.0011	0.998	0.0038	0.01	1.01
191		./pust.015/case_10	2.891	8.98E-06	201.29	0.014	2.37E-01	3.10E-04	1.004	0.0012	0.9971	0.0047	0.007	1.007
192		./pust.015/case_11	2.891	8.53E-06	201.2	0.014	2.39E-01	3.35E-04	1.005	0.0012	0.9971	0.0047	0.007	1.008
193		./pust.015/case_12	2.891	9.18E-06	201.25	0.013	2.37E-01	3.05E-04	1.004	0.0011	0.9971	0.0047	0.007	1.007
194		./pust.015/case_13	2.891	8.57E-06	201.3	0.013	2.37E-01	3.13E-04	1.006	0.0011	0.9971	0.0047	0.009	1.009
195		./pust.015/case_14	2.891	8.58E-06	201.35	0.013	2.36E-01	2.99E-04	1.007	0.0012	0.9971	0.0047	0.01	1.01
196		./pust.015/case_15	2.891	8.98E-06	201.2	0.014	2.39E-01	3.23E-04	1.008	0.0012	0.9971	0.0047	0.01	1.01
197		./pust.015/case_16	2.891	8.88E-06	201.24	0.015	2.37E-01	3.22E-04	1.005	0.0013	0.9971	0.0047	0.007	1.008
198		./pust.015/case_17	2.891	8.92E-06	201.29	0.014	2.37E-01	3.01E-04	1.007	0.0014	0.9971	0.0047	0.01	1.01
199		./pust.015/case_2	2.891	9.40E-06	201.25	0.014	2.38E-01	3.31E-04	1.005	0.0011	0.998	0.0038	0.007	1.007
200		./pust.015/case_3	2.891	8.83E-06	201.26	0.014	2.37E-01	3.23E-04	1.004	0.0014	0.998	0.0038	0.006	1.006
201		./pust.015/case_4	2.891	9.07E-06	201.31	0.014	2.36E-01	3.16E-04	1.006	0.0013	0.998	0.0038	0.008	1.008
202		./pust.015/case_5	2.891	8.97E-06	201.29	0.014	2.37E-01	3.11E-04	1.006	0.0013	0.998	0.0038	0.008	1.008
203		./pust.015/case_6	2.891	8.96E-06	201.32	0.014	2.36E-01	3.04E-04	1.007	0.0013	0.998	0.0038	0.009	1.009
204		./pust.015/case_7	2.891	8.46E-06	201.21	0.014	2.38E-01	3.23E-04	1.009	0.0011	0.9971	0.0047	0.012	1.012
205		./pust.015/case_8	2.891	9.03E-06	201.24	0.015	2.38E-01	3.34E-04	1.005	0.0012	0.9971	0.0047	0.007	1.007
206		./pust.015/case_9	2.891	8.74E-06	201.29	0.014	2.37E-01	3.27E-04	1.008	0.0013	0.9971	0.0047	0.011	1.011
207	ST016	./pust.016/case_1	2.891	9.29E-06	201.25	0.014	2.37E-01	3.24E-04	1.006	0.0015	0.998	0.0043	0.008	1.008
208		./pust.016/case_10	2.891	7.41E-06	205.56	0.011	1.66E-01	1.95E-04	1.006	0.0014	0.9963	0.0033	0.01	1.01
209		./pust.016/case_11	2.891	7.15E-06	205.52	0.011	1.67E-01	1.92E-04	1.008	0.0014	0.9963	0.0033	0.012	1.012
210		./pust.016/case_2	2.891	9.00E-06	201.28	0.014	2.37E-01	3.21E-04	1.006	0.0012	0.998	0.0043	0.008	1.008

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
211		./pust.016/case_3	2.891	9.27E-06	201.29	0.015	2.37E-01	3.42E-04	1.007	0.0012	0.998	0.0043	0.009	1.009
212		./pust.016/case_4	2.891	8.70E-06	201.29	0.014	2.37E-01	3.24E-04	1.008	0.0013	0.998	0.0043	0.01	1.01
213		./pust.016/case_5	2.891	7.07E-06	205.47	0.011	1.67E-01	1.90E-04	1.007	0.0012	0.9969	0.0038	0.01	1.01
214		./pust.016/case_6	2.891	6.89E-06	205.47	0.012	1.67E-01	2.07E-04	1.007	0.0014	0.9969	0.0038	0.01	1.01
215		./pust.016/case_7	2.891	7.17E-06	205.5	0.011	1.67E-01	2.05E-04	1.007	0.0015	0.9969	0.0038	0.011	1.011
216		./pust.016/case_8	2.891	6.61E-06	205.51	0.011	1.67E-01	1.89E-04	1.007	0.0015	0.9969	0.0038	0.01	1.01
217		./pust.016/case_9	2.891	7.26E-06	205.61	0.011	1.65E-01	1.92E-04	1.008	0.0014	0.9963	0.0033	0.012	1.012
218	ST017	./pust.017/case_1	2.891	7.62E-06	205.51	0.011	1.67E-01	1.98E-04	1.003	0.0013	0.9969	0.0038	0.006	1.006
219		./pust.017/case_10	2.891	7.17E-06	205.5	0.012	1.67E-01	2.11E-04	1.007	0.0013	0.9969	0.0038	0.01	1.01
220		./pust.017/case_11	2.891	7.63E-06	205.54	0.012	1.67E-01	2.06E-04	1.006	0.0014	0.9969	0.0038	0.009	1.009
221		./pust.017/case_12	2.891	7.22E-06	205.48	0.011	1.67E-01	1.97E-04	1.006	0.0012	0.9969	0.0038	0.009	1.009
222		./pust.017/case_13	2.891	7.64E-06	205.52	0.012	1.67E-01	2.02E-04	1.005	0.0012	0.9969	0.0038	0.008	1.008
223		./pust.017/case_14	2.891	7.15E-06	205.49	0.011	1.67E-01	1.97E-04	1.005	0.0012	0.9969	0.0038	0.008	1.008
224		./pust.017/case_15	2.891	6.83E-06	205.53	0.012	1.67E-01	2.04E-04	1.007	0.0012	0.9969	0.0038	0.01	1.01
225		./pust.017/case_16	2.891	7.52E-06	205.53	0.011	1.67E-01	1.96E-04	1.008	0.0013	0.9969	0.0038	0.011	1.011
226		./pust.017/case_17	2.891	7.34E-06	205.52	0.012	1.67E-01	2.12E-04	1.008	0.0013	0.9969	0.0038	0.011	1.011
227		./pust.017/case_18	2.891	7.44E-06	205.5	0.012	1.67E-01	2.06E-04	1.005	0.0014	0.9969	0.0038	0.008	1.008
228		./pust.017/case_2	2.891	7.43E-06	205.51	0.012	1.67E-01	2.10E-04	1.006	0.0013	0.9969	0.0038	0.009	1.009
229		./pust.017/case_3	2.891	7.73E-06	205.52	0.011	1.67E-01	1.95E-04	1.004	0.0014	0.9969	0.0038	0.007	1.007
230		./pust.017/case_4	2.891	7.10E-06	205.51	0.012	1.67E-01	2.03E-04	1.006	0.0013	0.9969	0.0038	0.01	1.01
231		./pust.017/case_5	2.891	7.73E-06	205.5	0.011	1.67E-01	2.04E-04	1.005	0.0013	0.9969	0.0038	0.008	1.008
232		./pust.017/case_6	2.891	7.40E-06	205.5	0.012	1.67E-01	2.05E-04	1.006	0.0012	0.9969	0.0038	0.009	1.009
233		./pust.017/case_7	2.891	7.28E-06	205.48	0.011	1.67E-01	1.98E-04	1.004	0.0013	0.9969	0.0038	0.007	1.007
234		./pust.017/case_8	2.891	7.30E-06	205.49	0.011	1.67E-01	1.97E-04	1.006	0.0012	0.9969	0.0038	0.009	1.009
235		./pust.017/case_9	2.891	7.33E-06	205.52	0.012	1.67E-01	1.98E-04	1.005	0.0011	0.9969	0.0038	0.008	1.008
236	ST020	./pust.020/case_1_t8a	2.891	3.82E-06	215.48	0.005	6.56E-02	4.96E-05	1.008	0.001	0.9969	0.0038	0.011	1.011
237		./pust.020/case_2_t8a	2.891	3.52E-06	215.62	0.005	6.46E-02	4.39E-05	1.009	0.0012	0.9969	0.0038	0.013	1.013

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
238		./pust.020/case_3_t8a	2.891	3.63E-06	216.5	0.005	5.89E-02	4.08E-05	1.004	0.001	0.9969	0.0038	0.007	1.007
239		./pust.020/case_5_t8a	2.891	4.43E-06	213.98	0.007	7.64E-02	6.38E-05	1.009	0.0012	0.9969	0.0038	0.012	1.012
240		./pust.020/case_6_t8a	2.891	4.54E-06	213.63	0.007	7.91E-02	6.98E-05	1.009	0.001	0.9969	0.0038	0.012	1.012
241		./pust.020/case_7_t8a	2.891	3.63E-06	216.27	0.005	6.03E-02	3.98E-05	1.004	0.0011	0.9969	0.0038	0.007	1.007
242		./pust.020/case_8_t8a	2.891	5.38E-06	210.64	0.008	1.06E-01	1.04E-04	1.007	0.0013	0.9969	0.0038	0.011	1.011
243		./pust.020/case_9_t8a	2.891	3.91E-06	214.04	0.006	7.60E-02	5.98E-05	0.999	0.0011	0.9969	0.0038	0.002	1.002
244	ST021	./pust.021/case_10	2.892	2.59E-06	218.03	0.003	4.98E-02	2.60E-05	1.011	0.0009	1	0.0025	0.011	1.011
245		./pust.021/case_7	2.891	3.63E-06	215.4	0.005	6.60E-02	4.69E-05	1.013	0.0013	1	0.0032	0.013	1.013
246		./pust.021/case_8	2.891	9.83E-06	197.73	0.017	3.13E-01	4.72E-04	1.004	0.0011	1	0.0065	0.004	1.004
247		./pust.021/case_9	2.891	3.90E-06	215.14	0.005	6.78E-02	5.09E-05	1.015	0.0013	1	0.0032	0.015	1.015
248	ST024	./pust.024/case_1	2.897	1.38E-05	191.71	0.019	4.71E-01	7.56E-04	1	0.0012	1	0.0062	0	1
249		./pust.024/case_10	2.895	9.04E-06	201.34	0.014	2.26E-01	3.05E-04	1.009	0.0011	1	0.0053	0.009	1.009
250		./pust.024/case_11	2.895	9.28E-06	201.41	0.014	2.25E-01	2.97E-04	1.008	0.0011	1	0.0053	0.008	1.008
251		./pust.024/case_12	2.895	9.02E-06	201.47	0.015	2.24E-01	3.11E-04	1.006	0.0012	1	0.0053	0.006	1.006
252		./pust.024/case_13	2.895	9.30E-06	201.46	0.014	2.24E-01	2.99E-04	1.007	0.0011	1	0.0053	0.007	1.007
253		./pust.024/case_14	2.896	1.14E-05	197.75	0.016	2.99E-01	4.37E-04	1.005	0.0011	1	0.0053	0.005	1.005
254		./pust.024/case_15	2.896	1.11E-05	197.81	0.017	2.98E-01	4.28E-04	1.003	0.0013	1	0.0053	0.003	1.003
255		./pust.024/case_16	2.896	1.10E-05	197.86	0.016	2.97E-01	4.29E-04	1.003	0.0012	1	0.0053	0.003	1.003
256		./pust.024/case_17	2.896	1.06E-05	197.96	0.017	2.94E-01	4.46E-04	1.001	0.0012	1	0.0053	0.001	1.001
257		./pust.024/case_18	2.895	5.05E-06	212.04	0.007	9.02E-02	7.86E-05	1.008	0.0012	1	0.0051	0.008	1.008
258		./pust.024/case_19	2.895	5.42E-06	212.05	0.007	9.02E-02	7.71E-05	1.009	0.001	1	0.0051	0.009	1.009
259		./pust.024/case_2	2.897	1.43E-05	191.88	0.021	4.64E-01	8.09E-04	1.001	0.0011	1	0.0062	0.001	1.001
260		./pust.024/case_20	2.895	5.22E-06	212.09	0.007	8.98E-02	7.64E-05	1.01	0.0012	1	0.0051	0.01	1.01
261		./pust.024/case_21	2.895	5.06E-06	212.11	0.007	8.96E-02	7.74E-05	1.008	0.0012	1	0.0051	0.008	1.008
262		./pust.024/case_22	2.895	5.20E-06	212.15	0.007	8.93E-02	7.95E-05	1.006	0.0012	1	0.0051	0.006	1.006
263		./pust.024/case_23	2.895	5.26E-06	212.16	0.007	8.92E-02	7.65E-05	1.006	0.0011	1	0.0051	0.006	1.006
264		./pust.024/case_3	2.897	1.42E-05	191.92	0.021	4.63E-01	7.99E-04	0.999	0.001	1	0.0062	-0.001	0.999

Results for Volume 1: Plutonium Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc Pu	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff Pu*
265		./pust.024/case_4	2.897	1.34E-05	192.02	0.02	4.59E-01	7.43E-04	1	0.0011	1	0.0062	0	1
266		./pust.024/case_5	2.897	1.42E-05	192.06	0.02	4.57E-01	7.91E-04	0.998	0.0012	1	0.0062	-0.002	0.998
267		./pust.024/case_6	2.903	2.47E-05	173.48	0.031	1.68E+00	3.75E-03	0.997	0.0011	1	0.0077	-0.003	0.997
268		./pust.024/case_7	2.896	9.74E-06	201.14	0.014	2.30E-01	3.01E-04	1.008	0.0011	1	0.0053	0.008	1.008
269		./pust.024/case_8	2.895	9.15E-06	201.2	0.015	2.29E-01	3.10E-04	1.01	0.0015	1	0.0053	0.01	1.01
270		./pust.024/case_9	2.896	9.56E-06	201.25	0.015	2.28E-01	3.19E-04	1.007	0.001	1	0.0053	0.007	1.007
		Maximum	3.137	7.86E-04	219.8	0.09	1.26E+06	2.38E+03	1.0041	0.011	1.0041	0.011	0.033	1.033
		Average	2.94	7.43E-05	165.5	0.017	1.74E+05	2.89E+02	0.9992	0.004	0.9992	0.004	0.006	1.006
		Minimum	2.891	1.63E-06	21.23	0.002	4.06E-02	1.30E-05	0.9963	0.001	0.9963	0.001	-0.017	0.983

Table 4.2 Results for Highly Enriched Uranium Systems (Volume 2) with CSAS25 from SCALE 4.4a and the 238-group Library on the J-5600 (CMODB) Workstation

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
1	heucm.001/hcm001_02	192.7	4.47E-02	3.82E-01	1.26E-03	1.00853	0.00097	1.0012	0.0059	0.0073	1.00733
2	heucm.001/hcm001_06	92.3	8.60E-02	1.84E+03	1.34E+01	0.9931	0.00092	0.9953	0.0056	-0.0022	0.9978

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
3	heucm.001/hcm001_13	115.8	8.27E-02	2.34E+02	1.58E+00	0.99888	0.00088	1.0032	0.0053	-0.0043	0.99568
4	heucm.001/hcm001_17	142.2	8.29E-02	2.54E+01	1.71E-01	0.995	0.00097	0.9997	0.0046	-0.0047	0.9953
5	heucm.001/hcm001_20	99.7	7.42E-02	5.61E+02	3.21E+00	1.00596	0.00106	1.006	0.0065	0.0000	0.99996
6	heucm.001/hcm001_27	104.4	7.68E-02	3.97E+02	2.32E+00	0.99803	0.00095	0.9991	0.0053	-0.0011	0.99893
7	heucm.001/hcm001_28	101.8	7.83E-02	4.88E+02	2.93E+00	1.00403	0.00109	1.0037	0.0053	0.0003	1.00033
8	heuct.010/hct010a	180.5	4.38E-02	8.51E-01	2.52E-03	0.98579	0.00105	1	0.005	-0.0142	0.98579
9	heuct.010/hct010b	205.1	2.62E-02	1.38E-01	2.76E-04	0.99156	0.00103	1	0.005	-0.0084	0.99156
10	heuct.010/hct010c	209.9	2.17E-02	9.61E-02	1.64E-04	1.00111	0.00103	1	0.005	0.0011	1.00111
11	heuct.010/hct010d	209.3	2.23E-02	1.00E-01	1.72E-04	0.99926	0.00114	1	0.005	-0.0007	0.99926
12	heuct.010/hct010e	209.7	2.17E-02	9.73E-02	1.68E-04	1.00367	0.001	1.001	0.0074	0.0027	1.00267
13	heuct.010/hct010g	209.9	2.83E-02	9.21E-02	2.19E-04	1.00566	0.00097	1.0007	0.0076	0.0050	1.00496
14	heuct.011/case_1	182.6	4.48E-02	7.19E-01	2.08E-03	0.99432	0.00126	0.9988	0.0042	-0.0045	0.99552
15	heuct.011/case_2	186.2	4.11E-02	5.54E-01	1.53E-03	0.9946	0.00093	0.9988	0.0042	-0.0042	0.9958
16	heuct.011/case_3	189.6	4.00E-02	4.32E-01	1.15E-03	0.99546	0.0009	0.9988	0.0042	-0.0033	0.99666
17	heuct.012/case_1	185.1	4.36E-02	6.02E-01	1.69E-03	0.99229	0.00096	0.9987	0.0032	-0.0064	0.99359
18	heuct.012/case_2	188.8	4.21E-02	4.58E-01	1.27E-03	0.99294	0.00091	0.9987	0.0034	-0.0058	0.99424
19	heuct.013/case_1	188.9	4.30E-02	4.54E-01	1.32E-03	0.99565	0.00114	0.9988	0.0042	-0.0031	0.99685
20	heuct.013/case_2	193.8	4.06E-02	3.16E-01	8.43E-04	0.9952	0.00099	0.9988	0.0043	-0.0036	0.9964
21	heuct.014/case_1	206.9	3.06E-02	1.17E-01	2.60E-04	0.99989	0.00099	0.9986	0.0048	0.0013	1.00129
22	heuct.014/case_2	209.3	2.92E-02	9.71E-02	2.08E-04	1.00124	0.00091	0.9986	0.0049	0.0026	1.00264
23	heumf.001/hmf001a	24.4	1.35E-02	9.49E+05	1.17E+03	0.99605	0.00094	1	0.001	-0.0040	0.99605
24	heumf.002/hmf002b	25.5	1.82E-02	8.38E+05	1.41E+03	1.00274	0.00106	1	0.003	0.0027	1.00274
25	heumf.002/hmf002c	25.5	1.91E-02	8.35E+05	1.46E+03	0.99918	0.0009	1	0.003	-0.0008	0.99918
26	heumf.002/hmf002d	25.6	1.92E-02	8.24E+05	1.45E+03	0.99523	0.001	1	0.003	-0.0048	0.99523
27	heumf.002/hmf002e	25.7	1.84E-02	8.18E+05	1.37E+03	1.00336	0.00089	1	0.003	0.0034	1.00336
28	heumf.002/hmf002g	25.6	1.79E-02	8.26E+05	1.38E+03	0.99832	0.00094	1	0.003	-0.0017	0.99832
29	heumf.003/hmf003a	24.8	1.30E-02	9.10E+05	1.13E+03	0.99233	0.00084	1	0.005	-0.0077	0.99233

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
30	heumf.003/hmf003b	24.9	1.40E-02	8.99E+05	1.18E+03	0.99359	0.0009	1	0.005	-0.0064	0.99359
31	heumf.003/hmf003c	25.0	1.34E-02	8.87E+05	1.15E+03	0.99839	0.00098	1	0.005	-0.0016	0.99839
32	heumf.003/hmf003d	25.1	1.39E-02	8.78E+05	1.19E+03	0.99795	0.00101	1	0.003	-0.0021	0.99795
33	heumf.003/hmf003e	25.3	1.54E-02	8.58E+05	1.24E+03	1.00189	0.00099	1	0.003	0.0019	1.00189
34	heumf.003/hmf003g	25.3	1.62E-02	8.53E+05	1.27E+03	1.00052	0.00106	1	0.003	0.0005	1.00052
35	heumf.003/hmf003h	25.5	1.95E-02	8.31E+05	1.48E+03	1.0031	0.0011	1	0.003	0.0031	1.0031
36	heumf.003/hmf003i	27.2	1.33E-02	7.12E+05	9.38E+02	1.00297	0.00091	1	0.005	0.0030	1.00297
37	heumf.003/hmf003j	28.1	1.37E-02	6.41E+05	9.03E+02	1.00505	0.00082	1	0.005	0.0051	1.00505
38	heumf.003/hmf003k	28.9	1.45E-02	5.83E+05	8.81E+02	1.01025	0.001	1	0.005	0.0103	1.01025
39	heumf.003/hmf003l	29.1	1.36E-02	5.64E+05	8.19E+02	1.0127	0.0008	1	0.005	0.0127	1.0127
40	heumf.004/hmf004d	61.1	7.45E-02	3.16E+04	2.05E+02	0.9964	0.00112	1.002	0	-0.0056	0.9944
41	heumf.007/case_1	24.3	1.31E-02	9.57E+05	1.18E+03	0.99113	0.00104	0.9971	0.0001	-0.0060	0.99403
42	heumf.007/case_10	55.0	5.08E-02	2.84E+04	1.35E+02	0.99248	0.00103	1	0.0001	-0.0075	0.99248
43	heumf.007/case_11	70.1	6.42E-02	5.92E+03	3.34E+01	0.99257	0.00129	0.9982	0.0001	-0.0056	0.99437
44	heumf.007/case_12	73.6	6.66E-02	4.33E+03	2.42E+01	0.9908	0.00112	0.9951	0.0001	-0.0043	0.9957
45	heumf.007/case_13	82.1	7.20E-02	2.69E+03	1.62E+01	0.99667	0.00107	1.0009	0.0001	-0.0042	0.99577
46	heumf.007/case_14	74.6	6.45E-02	3.97E+03	2.23E+01	0.99203	0.00115	0.9983	0.0001	-0.0063	0.99373
47	heumf.007/case_15	80.7	6.91E-02	3.00E+03	1.72E+01	0.99041	0.00103	0.9978	0.0001	-0.0074	0.99261
48	heumf.007/case_16	80.9	7.71E-02	2.95E+03	1.88E+01	0.99122	0.00116	0.9988	0.0001	-0.0076	0.99242
49	heumf.007/case_17	103.2	7.88E-02	3.86E+02	2.37E+00	0.99168	0.00152	0.9972	0.0001	-0.0055	0.99448
50	heumf.007/case_18	103.8	7.78E-02	3.68E+02	2.24E+00	0.99515	0.00117	0.9991	0.0001	-0.0040	0.99605
51	heumf.007/case_19	24.3	1.27E-02	9.54E+05	1.12E+03	0.99294	0.00097	0.9983	0.0001	-0.0054	0.99464
52	heumf.007/case_2	28.7	1.93E-02	5.29E+05	1.17E+03	0.9938	0.00106	0.9986	0.0001	-0.0048	0.9952
53	heumf.007/case_20	35.7	3.37E-02	2.29E+05	8.20E+02	0.99117	0.00118	0.9981	0.0001	-0.0069	0.99307
54	heumf.007/case_21	36.4	3.60E-02	2.12E+05	8.04E+02	0.99211	0.00093	0.9987	0.0001	-0.0066	0.99341
55	heumf.007/case_22	37.2	3.45E-02	1.94E+05	6.93E+02	0.99284	0.00098	0.9994	0.0001	-0.0066	0.99344
56	heumf.007/case_23	48.5	5.80E-02	6.60E+04	3.52E+02	0.99408	0.0009	0.9993	0.0001	-0.0052	0.99478

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
57	heumf.007/case_24	49.2	5.68E-02	6.23E+04	3.23E+02	0.99447	0.00112	1.0001	0.0001	-0.0056	0.99437
58	heumf.007/case_25	57.1	6.29E-02	2.80E+04	1.58E+02	0.99493	0.00109	0.999	0.0001	-0.0041	0.99593
59	heumf.007/case_26	57.9	6.03E-02	2.62E+04	1.43E+02	0.99366	0.00105	0.9997	0.0001	-0.0060	0.99396
60	heumf.007/case_27	29.2	2.08E-02	4.97E+05	1.20E+03	0.99052	0.00107	0.9965	0.0002	-0.0060	0.99402
61	heumf.007/case_28	33.2	2.55E-02	2.99E+05	8.79E+02	0.99132	0.00085	0.9987	0.0002	-0.0074	0.99262
62	heumf.007/case_29	37.5	3.28E-02	1.73E+05	6.22E+02	0.99254	0.00089	0.9978	0.0002	-0.0053	0.99474
63	heumf.007/case_3	31.0	2.54E-02	4.02E+05	1.14E+03	0.99399	0.00099	1.0012	0.0001	-0.0072	0.99279
64	heumf.007/case_30	59.5	5.75E-02	1.86E+04	9.91E+01	0.99153	0.00096	0.9981	0.0002	-0.0066	0.99343
65	heumf.007/case_31	84.4	6.74E-02	1.73E+03	9.64E+00	0.99799	0.00117	1.0013	0.0002	-0.0033	0.99669
66	heumf.007/case_32	25.5	1.31E-02	8.40E+05	1.08E+03	0.99807	0.00087	0.9959	0.0001	0.0022	1.00217
67	heumf.007/case_33	26.3	1.38E-02	7.69E+05	1.05E+03	1.00516	0.00103	0.9995	0.0001	0.0057	1.00566
68	heumf.007/case_34	27.0	1.49E-02	7.05E+05	1.05E+03	1.00941	0.00095	0.9977	0.0001	0.0117	1.01171
69	heumf.007/case_35	76.1	7.88E-02	7.88E+03	5.42E+01	0.99206	0.00099	1.0011	0.0001	-0.0090	0.99096
70	heumf.007/case_36	81.8	8.40E-02	3.92E+03	2.78E+01	0.99863	0.0009	0.9999	0.0001	-0.0013	0.99873
71	heumf.007/case_37	88.0	7.87E-02	1.96E+03	1.25E+01	0.99808	0.00099	0.9988	0.0001	-0.0007	0.99928
72	heumf.007/case_38	88.7	8.13E-02	1.77E+03	1.17E+01	0.99853	0.0011	1	0.0001	-0.0015	0.99853
73	heumf.007/case_39	88.8	7.59E-02	1.73E+03	1.09E+01	0.99997	0.00093	1.0018	0.0001	-0.0018	0.99817
74	heumf.007/case_4	31.8	2.55E-02	3.54E+05	1.06E+03	0.99179	0.00103	0.997	0.0001	-0.0052	0.99479
75	heumf.007/case_40	89.0	7.74E-02	1.78E+03	1.12E+01	1.0031	0.00095	1.0013	0.0001	0.0018	1.0018
76	heumf.007/case_41	106.5	8.13E-02	3.26E+02	2.06E+00	0.99935	0.00116	0.9994	0.0001	0.0000	0.99995
77	heumf.007/case_42	107.2	7.80E-02	3.07E+02	1.87E+00	0.9995	0.00091	1.0016	0.0001	-0.0021	0.9979
78	heumf.007/case_43	132.1	7.26E-02	3.48E+01	1.88E-01	1.00107	0.0012	0.9998	0.0001	0.0013	1.00127
79	heumf.007/case_5	33.8	2.66E-02	2.71E+05	8.50E+02	0.99267	0.00095	1	0.0001	-0.0073	0.99267
80	heumf.007/case_6	38.5	3.87E-02	1.71E+05	6.92E+02	0.99982	0.00108	1.0028	0.0001	-0.0030	0.99702
81	heumf.007/case_7	35.8	3.11E-02	2.13E+05	7.59E+02	0.99619	0.00116	0.9996	0.0001	-0.0034	0.99659
82	heumf.007/case_8	35.4	3.00E-02	2.18E+05	7.69E+02	0.99183	0.00103	0.9992	0.0001	-0.0074	0.99263
83	heumf.007/case_9	37.0	3.50E-02	1.93E+05	7.29E+02	0.9959	0.0011	1.0017	0.0008	-0.0058	0.9942

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
84	heumf.018/hmf018a	24.6	1.27E-02	9.29E+05	1.11E+03	0.99769	0.00102	1	0.0014	-0.0023	0.99769
85	heumf.019/hmf019a	25.4	1.29E-02	8.58E+05	1.06E+03	1.00212	0.00085	1	0.0028	0.0021	1.00212
86	heumf.020/hmf020a	30.0	3.05E-02	5.09E+05	1.51E+03	0.99438	0.00098	1	0.0028	-0.0056	0.99438
87	heumf.021/hmf021a	25.9	1.28E-02	8.21E+05	1.01E+03	1.01458	0.00095	1	0.0024	0.0146	1.01458
88	heumf.022/hmf022a	25.1	1.29E-02	8.91E+05	1.09E+03	0.99116	0.00103	1	0.0019	-0.0088	0.99116
89	heumf.023/hmf023e	24.6	1.53E-02	9.31E+05	1.32E+03	0.99692	0.00095	1	0.0052	-0.0031	0.99692
90	heumf.023/hmf023g	82.2	8.64E-02	5.30E+03	3.92E+01	0.99997	0.00101	1	0.0052	0.0000	0.99997
91	heumf.026/hmf026b	24.5	1.38E-02	9.42E+05	1.21E+03	0.9979	0.00096	0.9982	0.0042	-0.0003	0.9997
92	heumf.026/hmf026g	61.4	8.14E-02	3.18E+04	2.26E+02	1.00018	0.00089	1	0.0038	0.0002	1.00018
93	heumf.026/hmf026h	74.2	8.34E-02	1.12E+04	7.95E+01	0.99858	0.00096	1	0.0038	-0.0014	0.99858
94	heumf.026/hmf026j	30.0	3.35E-02	5.25E+05	1.64E+03	0.98957	0.00084	0.9982	0.0042	-0.0086	0.99137
95	heumf.026/hmf026l	69.7	7.77E-02	1.71E+04	1.14E+02	0.99961	0.00098	1	0.0038	-0.0004	0.99961
96	heumf.027/hmf027a	25.0	1.24E-02	8.99E+05	1.07E+03	1.00872	0.00087	1	0.0025	0.0087	1.00872
97	heumf.028/hmf028b	25.3	1.60E-02	8.57E+05	1.28E+03	1.00469	0.00102	1	0.003	0.0047	1.00469
98	heumf.029/hmf029a	25.1	1.30E-02	8.86E+05	1.11E+03	1.00319	0.00103	1	0.002	0.0032	1.00319
99	heumf.030/hmf030a	35.1	3.53E-02	2.33E+05	9.34E+02	1.00397	0.00105	1	0.0009	0.0040	1.00397
100	heumf.031/hmf031b	76.6	7.82E-02	6.87E+03	4.62E+01	1.00099	0.00093	1	0.0059	0.0010	1.00099
101	heumf.032/hmf032d	25.0	1.42E-02	8.87E+05	1.21E+03	1.00413	0.00092	1	0.0016	0.0041	1.00413
102	heumf.032/hmf032e	25.0	1.30E-02	8.91E+05	1.12E+03	1.00038	0.00095	1	0.0027	0.0004	1.00038
103	heumf.032/hmf032g	24.8	1.27E-02	9.13E+05	1.11E+03	0.99885	0.00107	1	0.0017	-0.0011	0.99885
104	heumf.032/hmf032h	24.6	1.27E-02	9.29E+05	1.09E+03	0.9996	0.00108	1	0.0017	-0.0004	0.9996
105	heumf.034/hmf034a	63.1	6.80E-02	1.67E+04	9.84E+01	0.99319	0.00112	0.999	0.0012	-0.0058	0.99419
106	heumf.034/hmf034c	63.2	6.68E-02	1.68E+04	9.80E+01	0.99231	0.00114	0.999	0.0012	-0.0067	0.99331
107	heumf.034/hmf034e	64.7	6.59E-02	1.57E+04	8.94E+01	0.99978	0.0012	0.999	0.0012	0.0008	1.00078
108	heumm.001/hmm001a	87.2	8.08E-02	2.31E+03	1.56E+01	0.99972	0.00104	0.9995	0.0013	0.0002	1.00022
109	heumm.002/hmm002a	96.4	7.86E-02	1.17E+03	7.59E+00	1.00571	0.00097	1	0.0037	0.0057	1.00571
110	heumm.003/hmm003a	96.3	8.41E-02	1.18E+03	8.29E+00	1.00657	0.0009	1	0.0038	0.0066	1.00657

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
111	heumt.003/hmt003a	66.4	7.73E-02	1.94E+04	1.30E+02	0.9969	0.00105	1	0.001	-0.0031	0.9969
112	heumt.003/hmt003b	67.1	8.06E-02	1.81E+04	1.27E+02	0.9762	0.00087	0.991	0.003	-0.0148	0.9852
113	heumt.003/hmt003c	112.2	8.00E-02	2.34E+02	1.47E+00	0.96808	0.00098	0.9826	0.006	-0.0145	0.98548
114	heumt.003/hmt003d	131.8	8.27E-02	4.90E+01	3.16E-01	0.97501	0.00127	0.9876	0.004	-0.0126	0.98741
115	heumt.003/hmt003e	166.8	6.67E-02	2.83E+00	1.40E-02	0.98934	0.00112	0.993	0.003	-0.0037	0.99634
116	heumt.003/hmt003g	151.3	7.54E-02	9.14E+00	5.16E-02	0.96856	0.00097	0.9889	0.003	-0.0203	0.97966
117	heumt.003/hmt003h	166.0	6.87E-02	3.01E+00	1.54E-02	0.97751	0.00106	0.9919	0.003	-0.0144	0.98561
118	heumt.006/case_1	210.0	2.67E-02	8.50E-02	1.70E-04	0.99769	0.00119	1	0.004	-0.0023	0.99769
119	heumt.006/case_10	210.4	2.81E-02	8.24E-02	1.73E-04	1.00684	0.00109	1	0.004	0.0068	1.00684
120	heumt.006/case_11	213.9	2.31E-02	6.20E-02	1.18E-04	1.00598	0.0011	1	0.004	0.0060	1.00598
121	heumt.006/case_12	215.7	1.96E-02	5.35E-02	8.83E-05	1.00561	0.00104	1	0.004	0.0056	1.00561
122	heumt.006/case_13	210.3	2.52E-02	8.29E-02	1.62E-04	1.02842	0.00118	1	0.004	0.0284	1.02842
123	heumt.006/case_14	215.0	2.04E-02	5.63E-02	9.49E-05	0.99794	0.00103	1	0.004	-0.0021	0.99794
124	heumt.006/case_15	215.1	2.06E-02	5.60E-02	9.80E-05	0.99419	0.00106	1	0.004	-0.0058	0.99419
125	heumt.006/case_16	213.7	2.23E-02	6.29E-02	1.13E-04	1.00521	0.00119	1	0.004	0.0052	1.00521
126	heumt.006/case_17	211.8	2.55E-02	7.37E-02	1.46E-04	1.00387	0.00106	1	0.004	0.0039	1.00387
127	heumt.006/case_18	210.8	2.73E-02	7.95E-02	1.68E-04	1.00375	0.00119	1	0.004	0.0037	1.00375
128	heumt.006/case_19	215.6	2.22E-02	5.21E-02	9.89E-05	0.99379	0.00102	1	0.004	-0.0062	0.99379
129	heumt.006/case_2	212.4	2.56E-02	7.00E-02	1.39E-04	1.00081	0.00105	1	0.004	0.0008	1.00081
130	heumt.006/case_20	213.3	2.31E-02	6.42E-02	1.21E-04	0.9968	0.00094	1	0.004	-0.0032	0.9968
131	heumt.006/case_21	212.5	2.48E-02	6.93E-02	1.30E-04	0.99808	0.00115	1	0.004	-0.0019	0.99808
132	heumt.006/case_22	211.8	2.55E-02	7.37E-02	1.45E-04	1.00322	0.001	1	0.004	0.0032	1.00322
133	heumt.006/case_23	211.5	2.52E-02	7.55E-02	1.46E-04	1.00611	0.00086	1	0.004	0.0061	1.00611
134	heumt.006/case_3	213.7	2.35E-02	6.26E-02	1.17E-04	1.00649	0.00098	1	0.004	0.0065	1.00649
135	heumt.006/case_4	214.0	2.24E-02	6.12E-02	1.15E-04	0.99486	0.00132	1	0.004	-0.0051	0.99486
136	heumt.006/case_5	214.7	2.02E-02	5.77E-02	9.78E-05	1.00156	0.00098	1	0.004	0.0016	1.00156
137	heumt.006/case_6	215.3	1.94E-02	5.53E-02	9.41E-05	1.00134	0.00088	1	0.004	0.0013	1.00134

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
138	heumt.006/case_7	215.7	2.08E-02	5.35E-02	9.24E-05	0.99826	0.00097	1	0.004	-0.0017	0.99826
139	heumt.006/case_8	216.1	2.02E-02	5.17E-02	8.94E-05	0.99467	0.00107	1	0.004	-0.0053	0.99467
140	heumt.006/case_9	216.2	2.07E-02	5.12E-02	8.89E-05	0.99238	0.00108	1	0.004	-0.0076	0.99238
141	heust.001/case_1	210.2	9.41E-03	8.16E-02	6.96E-05	0.99982	0.00129	1	0.0025	-0.0002	0.99982
142	heust.001/case_10	216.7	4.62E-03	4.58E-02	2.43E-05	0.99287	0.00138	1	0.0025	-0.0071	0.99287
143	heust.001/case_2	195.1	1.92E-02	2.79E-01	4.29E-04	0.99784	0.00129	1	0.0025	-0.0022	0.99784
144	heust.001/case_3	210.4	8.66E-03	8.01E-02	6.82E-05	1.00289	0.00122	1	0.0025	0.0029	1.00289
145	heust.001/case_4	194.3	1.88E-02	2.98E-01	4.56E-04	1.00024	0.00122	1	0.0025	0.0002	1.00024
146	heust.001/case_5	217.5	3.88E-03	4.26E-02	1.99E-05	1.00505	0.00113	1	0.0025	0.0051	1.00505
147	heust.001/case_6	217.1	4.37E-03	4.42E-02	2.20E-05	1.00384	0.0014	1	0.0025	0.0038	1.00384
148	heust.001/case_7	210.8	8.75E-03	7.72E-02	6.48E-05	1.00245	0.00121	1	0.0025	0.0025	1.00245
149	heust.001/case_8	210.2	9.11E-03	8.16E-02	6.83E-05	1.00286	0.00142	1	0.0025	0.0029	1.00286
150	heust.001/case_9	194.2	1.95E-02	2.98E-01	4.64E-04	0.99736	0.00132	1	0.0025	-0.0026	0.99736
151	heust.002/case_1	210.5	8.74E-03	7.97E-02	6.76E-05	1.00567	0.00128	1	0.002	0.0057	1.00567
152	heust.002/case_10	217.3	4.13E-03	4.37E-02	2.19E-05	1.0087	0.00128	1	0.002	0.0087	1.0087
153	heust.002/case_11	210.5	8.69E-03	7.95E-02	6.65E-05	1.00419	0.00146	1	0.002	0.0042	1.00419
154	heust.002/case_12	210.8	8.51E-03	7.76E-02	6.16E-05	1.00902	0.00126	1	0.002	0.0090	1.00902
155	heust.002/case_13	196.5	1.80E-02	2.49E-01	3.48E-04	1.00353	0.00147	1	0.002	0.0035	1.00353
156	heust.002/case_14	197.5	1.79E-02	2.32E-01	3.36E-04	1.00902	0.00125	1	0.002	0.0090	1.00902
157	heust.002/case_2	210.6	8.69E-03	7.91E-02	6.57E-05	1.00948	0.00127	1	0.002	0.0095	1.00948
158	heust.002/case_3	196.4	1.79E-02	2.51E-01	3.65E-04	1.00012	0.00121	1	0.002	0.0001	1.00012
159	heust.002/case_4	196.9	1.64E-02	2.43E-01	3.33E-04	1.00742	0.00139	1	0.002	0.0074	1.00742
160	heust.002/case_5	210.5	8.86E-03	7.95E-02	6.57E-05	1.00632	0.00131	1	0.002	0.0063	1.00632
161	heust.002/case_6	210.7	8.70E-03	7.80E-02	6.54E-05	1.01045	0.00142	1	0.002	0.0105	1.01045
162	heust.002/case_7	196.5	1.73E-02	2.49E-01	3.49E-04	1.00468	0.00142	1	0.002	0.0047	1.00468
163	heust.002/case_8	197.2	1.71E-02	2.37E-01	3.25E-04	1.00501	0.00134	1	0.002	0.0050	1.00501
164	heust.002/case_9	217.2	4.21E-03	4.40E-02	2.27E-05	1.00313	0.00135	1	0.002	0.0031	1.00313

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
165	heust.003/case_1	217.3	4.10E-03	4.38E-02	2.11E-05	1.0049	0.00129	1	0.005	0.0049	1.0049
166	heust.003/case_10	196.0	1.79E-02	2.60E-01	3.69E-04	0.99993	0.00141	1	0.005	-0.0001	0.99993
167	heust.003/case_11	197.5	1.87E-02	2.32E-01	3.47E-04	1.00253	0.00137	1	0.005	0.0025	1.00253
168	heust.003/case_12	217.2	4.15E-03	4.40E-02	2.20E-05	1.00222	0.00127	1	0.005	0.0022	1.00222
169	heust.003/case_13	217.4	3.97E-03	4.32E-02	2.03E-05	1.00266	0.00113	1	0.005	0.0027	1.00266
170	heust.003/case_14	217.2	4.21E-03	4.38E-02	2.22E-05	1.00212	0.00119	1	0.005	0.0021	1.00212
171	heust.003/case_15	216.9	4.35E-03	4.51E-02	2.16E-05	0.99622	0.00109	1	0.005	-0.0038	0.99622
172	heust.003/case_16	210.3	9.18E-03	8.07E-02	6.99E-05	1.00095	0.00133	1	0.005	0.0010	1.00095
173	heust.003/case_17	211.0	9.01E-03	7.63E-02	6.47E-05	1.00378	0.00142	1	0.005	0.0038	1.00378
174	heust.003/case_18	196.0	1.88E-02	2.60E-01	3.75E-04	0.99867	0.00125	1	0.005	-0.0013	0.99867
175	heust.003/case_19	197.9	1.78E-02	2.24E-01	3.13E-04	1.0019	0.00148	1	0.005	0.0019	1.0019
176	heust.003/case_2	217.2	4.19E-03	4.40E-02	2.25E-05	1.0055	0.00104	1	0.005	0.0055	1.0055
177	heust.003/case_3	210.3	8.70E-03	8.09E-02	6.76E-05	1.00152	0.00151	1	0.005	0.0015	1.00152
178	heust.003/case_4	210.6	8.97E-03	7.90E-02	6.61E-05	1.00463	0.00123	1	0.005	0.0046	1.00463
179	heust.003/case_5	195.8	1.77E-02	2.63E-01	3.70E-04	0.99717	0.00152	1	0.005	-0.0028	0.99717
180	heust.003/case_6	196.8	1.77E-02	2.45E-01	3.51E-04	0.99694	0.00148	1	0.005	-0.0031	0.99694
181	heust.003/case_7	217.4	4.16E-03	4.34E-02	2.08E-05	1.00462	0.00138	1	0.005	0.0046	1.00462
182	heust.003/case_8	210.3	8.91E-03	8.04E-02	6.55E-05	1.0033	0.00136	1	0.005	0.0033	1.0033
183	heust.003/case_9	210.9	9.09E-03	7.72E-02	6.62E-05	1.00748	0.00143	1	0.005	0.0075	1.00748
184	heust.004/hst004a	138.2	6.88E-02	1.34E+01	6.12E-02	1.00371	0.0012	1	0.0065	0.0037	1.00371
185	heust.004/hst004b	161.1	5.05E-02	2.72E+00	8.86E-03	1.00526	0.00114	1	0.0071	0.0053	1.00526
186	heust.004/hst004c	188.7	3.08E-02	4.24E-01	9.48E-04	1.00025	0.00139	1	0.0078	0.0003	1.00025
187	heust.004/hst004d	150.3	6.01E-02	5.64E+00	2.23E-02	0.99861	0.00115	1	0.0091	-0.0014	0.99861
188	heust.004/hst004e	174.8	4.36E-02	1.09E+00	3.18E-03	1.0067	0.00108	1	0.0104	0.0067	1.0067
189	heust.004/hst004g	199.2	1.94E-02	1.98E-01	2.99E-04	0.99836	0.00114	1	0.0117	-0.0016	0.99836
190	heust.005/hst005a	196.2	2.05E-02	2.47E-01	4.00E-04	1.00062	0.00105	1	0.0124	0.0006	1.00062
191	heust.005/hst005b	195.6	2.24E-02	2.56E-01	4.38E-04	1.00778	0.00105	1	0.0124	0.0078	1.00778

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
192	heust.005/hst005c	195.1	2.22E-02	2.67E-01	4.50E-04	1.00636	0.00105	1	0.0126	0.0064	1.00636
193	heust.005/hst005d	197.5	1.96E-02	2.26E-01	3.50E-04	1.0025	0.00121	1	0.0124	0.0025	1.0025
194	heust.005/hst005e	192.5	2.02E-02	3.28E-01	5.25E-04	0.98975	0.00089	1	0.0124	-0.0103	0.98975
195	heust.005/hst005g	196.4	2.08E-02	2.44E-01	3.94E-04	1.00525	0.001	1	0.0125	0.0052	1.00525
196	heust.005/hst005h	206.3	1.26E-02	1.11E-01	1.24E-04	1.00297	0.00109	1	0.0119	0.0030	1.00297
197	heust.005/hst005i	213.2	8.26E-03	6.23E-02	4.87E-05	1.00594	0.00119	1	0.0121	0.0059	1.00594
198	heust.006/hst006a	198.6	1.61E-02	2.11E-01	2.70E-04	0.98469	0.00143	0.9973	0.005	-0.0126	0.98739
199	heust.006/hst006b	189.1	1.58E-02	4.38E-01	5.35E-04	1.00256	0.00085	1	0.0087	0.0026	1.00256
200	heust.006/hst006c	196.1	1.68E-02	2.58E-01	3.46E-04	0.98773	0.0012	0.9986	0.0054	-0.0109	0.98913
201	heust.006/hst006d	191.7	1.52E-02	3.61E-01	4.34E-04	1.0008	0.00072	1	0.0078	0.0008	1.0008
202	heust.006/hst006e	190.1	1.52E-02	4.06E-01	4.85E-04	1.01075	0.00104	1	0.0091	0.0108	1.01075
203	heust.006/hst006g	193.3	1.61E-02	3.19E-01	4.00E-04	0.99989	0.00108	1	0.0065	-0.0001	0.99989
204	heust.006/hst006h	188.9	1.59E-02	4.45E-01	5.56E-04	1.00375	0.00072	1	0.0088	0.0037	1.00375
205	heust.007/case_1	216.5	4.93E-03	4.70E-02	2.60E-05	1.01325	0.00113	1	0.0035	0.0133	1.01325
206	heust.007/case_10	215.2	5.55E-03	5.26E-02	3.27E-05	1.01692	0.0012	1	0.0035	0.0169	1.01692
207	heust.007/case_11	196.1	1.82E-02	2.58E-01	3.67E-04	1.00742	0.00144	1	0.0035	0.0074	1.00742
208	heust.007/case_12	215.6	5.57E-03	5.08E-02	3.06E-05	1.01688	0.00115	1	0.0035	0.0169	1.01688
209	heust.007/case_13	197.4	1.77E-02	2.33E-01	3.23E-04	1.01163	0.00119	1	0.0035	0.0116	1.01163
210	heust.007/case_14	197.0	1.80E-02	2.40E-01	3.43E-04	1.0099	0.00118	1	0.0035	0.0099	1.0099
211	heust.007/case_15	196.9	1.84E-02	2.42E-01	3.47E-04	1.00849	0.00117	1	0.0035	0.0085	1.00849
212	heust.007/case_16	196.2	1.92E-02	2.56E-01	3.83E-04	1.0094	0.00106	1	0.0035	0.0094	1.0094
213	heust.007/case_17	197.0	1.91E-02	2.41E-01	3.62E-04	1.01066	0.00123	1	0.0035	0.0107	1.01066
214	heust.007/case_2	195.6	1.95E-02	2.69E-01	4.09E-04	1.01324	0.00121	1	0.005	0.0132	1.01324
215	heust.007/case_3	216.8	4.36E-03	4.58E-02	2.27E-05	1.01137	0.0011	1	0.0035	0.0114	1.01137
216	heust.007/case_4	197.1	1.81E-02	2.39E-01	3.42E-04	1.01219	0.00113	1	0.0035	0.0122	1.01219
217	heust.007/case_5	215.8	4.98E-03	5.00E-02	2.65E-05	1.00679	0.00117	1	0.0035	0.0068	1.00679
218	heust.007/case_6	195.3	1.77E-02	2.74E-01	3.91E-04	1.00436	0.00113	1	0.0035	0.0044	1.00436

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
219	heust.007/case_7	215.9	5.03E-03	4.93E-02	2.77E-05	1.00631	0.00123	1	0.0035	0.0063	1.00631
220	heust.007/case_8	195.4	1.88E-02	2.71E-01	3.99E-04	1.00375	0.00142	1	0.0035	0.0037	1.00375
221	heust.007/case_9	215.6	5.38E-03	5.09E-02	3.02E-05	1.00835	0.00098	1	0.0035	0.0084	1.00835
222	heust.008/case_1	217.2	4.24E-03	4.42E-02	2.19E-05	0.99836	0.00097	1	0.003	-0.0016	0.99836
223	heust.008/case_10	197.4	1.87E-02	2.33E-01	3.50E-04	0.9958	0.00128	1	0.003	-0.0042	0.9958
224	heust.008/case_11	217.7	4.20E-03	4.22E-02	2.13E-05	1.00152	0.00096	1	0.003	0.0015	1.00152
225	heust.008/case_12	199.1	1.80E-02	2.04E-01	2.96E-04	0.99676	0.00113	1	0.003	-0.0032	0.99676
226	heust.008/case_13	197.4	1.77E-02	2.32E-01	3.26E-04	0.99927	0.00136	1	0.003	-0.0007	0.99927
227	heust.008/case_14	198.7	1.97E-02	2.09E-01	3.26E-04	0.99577	0.00112	1	0.003	-0.0042	0.99577
228	heust.008/case_2	197.3	1.87E-02	2.36E-01	3.53E-04	0.99692	0.00102	1	0.003	-0.0031	0.99692
229	heust.008/case_3	217.5	4.00E-03	4.29E-02	1.99E-05	0.99756	0.00094	1	0.003	-0.0024	0.99756
230	heust.008/case_4	198.8	1.80E-02	2.09E-01	3.01E-04	0.9986	0.00134	1	0.003	-0.0014	0.9986
231	heust.008/case_5	217.2	4.32E-03	4.40E-02	2.21E-05	0.9986	0.00114	1	0.003	-0.0014	0.9986
232	heust.008/case_6	196.2	1.81E-02	2.56E-01	3.62E-04	0.99951	0.00129	1	0.003	-0.0005	0.99951
233	heust.008/case_7	217.4	4.15E-03	4.32E-02	2.17E-05	0.99933	0.00106	1	0.003	-0.0007	0.99933
234	heust.008/case_8	196.8	1.84E-02	2.44E-01	3.57E-04	0.99738	0.00133	1	0.003	-0.0026	0.99738
235	heust.008/case_9	217.3	4.14E-03	4.38E-02	2.23E-05	1.00086	0.00095	1	0.003	0.0009	1.00086
236	heust.009/hst009a	186.7	2.68E-02	5.28E-01	1.02E-03	1.00326	0.00124	1	0.0057	0.0033	1.00326
237	heust.009/hst009b	202.2	1.61E-02	1.60E-01	2.14E-04	1.00054	0.00124	1	0.0057	0.0005	1.00054
238	heust.009/hst009c	193.3	2.36E-02	3.23E-01	5.89E-04	1.00374	0.00121	1	0.0057	0.0037	1.00374
239	heust.009/hst009d	209.0	1.17E-02	9.11E-02	9.65E-05	0.99824	0.00149	1	0.0057	-0.0018	0.99824
240	heust.010/hst010e	215.4	5.76E-03	5.24E-02	3.22E-05	1.00306	0.00119	1	0.0018	0.0031	1.00306
241	heust.010/hst010g	215.2	6.43E-03	5.31E-02	3.59E-05	1.00121	0.00109	1	0.0018	0.0012	1.00121
242	heust.010/hst010h	214.8	6.27E-03	5.52E-02	3.59E-05	1.00325	0.00118	1	0.0018	0.0032	1.00325
243	heust.010/hst010i	214.6	6.68E-03	5.62E-02	3.84E-05	0.99967	0.00107	1	0.0018	-0.0003	0.99967
244	heust.011/hst011c	218.4	3.66E-03	3.96E-02	1.87E-05	1.00785	0.00102	1	0.002	0.0078	1.00785
245	heust.011/hst011d	218.5	3.45E-03	3.94E-02	1.70E-05	1.00248	0.00101	1	0.002	0.0025	1.00248

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
246	heust.012/hst012b	220.6	1.78E-03	3.24E-02	9.24E-06	1.00232	0.00073	0.9999	0.0058	0.0024	1.00242
247	heust.013/hst013e	220.6	1.67E-03	3.23E-02	8.82E-06	1.00013	0.00081	1.0012	0.0026	-0.0011	0.99893
248	heust.013/hst013g	220.1	1.90E-03	3.38E-02	9.94E-06	0.9991	0.00104	1.0007	0.0036	-0.0016	0.9984
249	heust.013/hst013h	219.7	2.21E-03	3.52E-02	1.13E-05	0.99531	0.00082	1.0009	0.0036	-0.0056	0.99441
250	heust.013/hst013i	219.5	2.32E-03	3.59E-02	1.18E-05	0.99653	0.00086	1.0003	0.0036	-0.0038	0.99623
251	heust.014/case_1	216.8	4.71E-03	4.56E-02	2.43E-05	0.99682	0.00107	1	0.0028	-0.0032	0.99682
252	heust.014/case_2	216.5	4.20E-03	4.72E-02	2.33E-05	1.01494	0.00102	1	0.0052	0.0149	1.01494
253	heust.014/case_3	216.1	4.15E-03	4.92E-02	2.45E-05	1.02365	0.00093	1	0.0087	0.0236	1.02365
254	heust.015/case_1	214.2	6.22E-03	5.74E-02	3.65E-05	0.99875	0.00131	1	0.0032	-0.0012	0.99875
255	heust.015/case_2	214.6	6.25E-03	5.57E-02	3.64E-05	0.99072	0.00115	1	0.0034	-0.0093	0.99072
256	heust.015/case_3	213.3	5.84E-03	6.26E-02	3.72E-05	1.01173	0.00104	1	0.0068	0.0117	1.01173
257	heust.015/case_4	213.7	6.05E-03	6.05E-02	3.78E-05	1.01776	0.00103	1	0.0069	0.0178	1.01776
258	heust.015/case_5	213.0	5.50E-03	6.52E-02	3.75E-05	1.01442	0.00085	1	0.0089	0.0144	1.01442
259	heust.016/case_1	210.7	9.34E-03	7.84E-02	6.91E-05	0.99042	0.00127	1	0.0036	-0.0096	0.99042
260	heust.016/case_2	210.3	7.92E-03	8.23E-02	6.12E-05	1.0094	0.00111	1	0.0069	0.0094	1.0094
261	heust.016/case_3	209.1	7.83E-03	9.15E-02	6.38E-05	1.03006	0.00089	1	0.0079	0.0301	1.03006
262	heust.017/case_1	208.1	1.11E-02	9.79E-02	9.51E-05	0.99199	0.00126	1	0.0028	-0.0080	0.99199
263	heust.017/case_2	206.9	1.11E-02	1.08E-01	1.05E-04	0.9814	0.00159	1	0.004	-0.0186	0.9814
264	heust.017/case_3	207.6	1.21E-02	1.02E-01	1.07E-04	0.98022	0.00126	1	0.0036	-0.0198	0.98022
265	heust.017/case_4	207.3	1.03E-02	1.05E-01	9.77E-05	1.00028	0.0011	1	0.0047	0.0003	1.00028
266	heust.017/case_5	206.8	1.03E-02	1.11E-01	1.04E-04	1.00877	0.00107	1	0.0058	0.0088	1.00877
267	heust.017/case_6	205.0	1.03E-02	1.28E-01	1.17E-04	1.00619	0.00101	1	0.0055	0.0062	1.00619
268	heust.017/case_7	205.9	1.07E-02	1.19E-01	1.10E-04	1.00987	0.00102	1	0.0057	0.0099	1.00987
269	heust.017/case_8	204.4	1.08E-02	1.36E-01	1.28E-04	1.0059	0.00102	1	0.0067	0.0059	1.0059
270	heust.018/case_1	202.1	1.57E-02	1.61E-01	2.09E-04	0.99072	0.00123	1	0.0034	-0.0093	0.99072
271	heust.018/case_10	195.6	1.43E-02	2.77E-01	3.14E-04	1.02573	0.001	1	0.0057	0.0257	1.02573
272	heust.018/case_11	197.1	1.32E-02	2.48E-01	2.58E-04	1.02842	0.00113	1	0.0059	0.0284	1.02842

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
273	heust.018/case_12	195.9	1.32E-02	2.74E-01	2.86E-04	1.02249	0.0008	1	0.0065	0.0225	1.02249
274	heust.018/case_2	200.1	1.66E-02	1.88E-01	2.57E-04	0.98288	0.00134	1	0.0046	-0.0171	0.98288
275	heust.018/case_3	201.3	1.50E-02	1.71E-01	2.15E-04	0.9902	0.00147	1	0.0042	-0.0098	0.9902
276	heust.018/case_4	200.9	1.42E-02	1.80E-01	2.08E-04	0.99888	0.00111	1	0.0044	-0.0011	0.99888
277	heust.018/case_5	198.0	1.44E-02	2.25E-01	2.60E-04	0.99636	0.00127	1	0.0046	-0.0036	0.99636
278	heust.018/case_6	199.2	1.52E-02	2.05E-01	2.53E-04	0.99399	0.00104	1	0.0045	-0.0060	0.99399
279	heust.018/case_7	199.6	1.35E-02	2.01E-01	2.22E-04	1.01211	0.001	1	0.0058	0.0121	1.01211
280	heust.018/case_8	197.0	1.53E-02	2.46E-01	3.03E-04	1.01196	0.00093	1	0.0056	0.0120	1.01196
281	heust.018/case_9	198.3	1.43E-02	2.22E-01	2.57E-04	1.01117	0.00096	1	0.0056	0.0112	1.01117
282	heust.019/case_1	193.6	2.15E-02	3.15E-01	5.34E-04	0.99939	0.0011	1	0.0041	-0.0006	0.99939
283	heust.019/case_2	194.6	1.99E-02	2.95E-01	4.56E-04	1.00263	0.00105	1	0.0041	0.0026	1.00263
284	heust.019/case_3	192.4	1.86E-02	3.51E-01	5.04E-04	0.99913	0.00105	1	0.0067	-0.0009	0.99913
285	heust.020/hst020g	172.5	2.85E-02	1.36E+00	2.62E-03	1.00619	0.00136	0.9966	0.0116	0.0096	1.00959
286	heust.020/hst020h	190.1	2.22E-02	3.97E-01	6.37E-04	1.00957	0.0014	0.9956	0.0093	0.0140	1.01397
287	heust.020/hst020i	204.4	1.39E-02	1.34E-01	1.58E-04	1.01668	0.0014	0.9957	0.0079	0.0210	1.02098
288	heust.020/hst020j	204.4	1.34E-02	1.34E-01	1.50E-04	1.01671	0.00142	0.9955	0.0078	0.0212	1.02121
289	heust.020/hst020k	214.3	6.86E-03	5.79E-02	4.15E-05	1.02228	0.00116	0.9959	0.0077	0.0264	1.02638
290	heust.021/hst021h	193.3	2.10E-02	3.22E-01	5.25E-04	1.00349	0.00121	0.9975	0.0054	0.0060	1.00599
291	heust.021/hst021i	198.4	2.00E-02	2.16E-01	3.38E-04	1.0105	0.00122	0.9975	0.0054	0.0130	1.013
292	heust.021/hst021j	192.9	1.97E-02	3.32E-01	5.05E-04	0.99427	0.00131	0.9978	0.0054	-0.0035	0.99647
293	heust.021/hst021k	194.8	1.77E-02	2.86E-01	4.08E-04	1.01397	0.00143	0.9978	0.0054	0.0162	1.01617
294	heust.021/hst021l	193.0	1.99E-02	3.29E-01	5.16E-04	0.99489	0.00113	0.9978	0.0054	-0.0029	0.99709
295	heust.021/hst021m	195.5	2.04E-02	2.69E-01	4.29E-04	0.99912	0.00122	0.9978	0.0054	0.0013	1.00132
296	heust.025/case_1	218.2	3.38E-03	4.01E-02	1.77E-05	1.00148	0.00096	1.0002	0.0025	0.0013	1.00128
297	heust.025/case_10	212.0	9.62E-03	7.01E-02	6.28E-05	1.0135	0.00097	1.0003	0.0043	0.0132	1.0132
298	heust.025/case_11	211.9	1.07E-02	7.11E-02	6.90E-05	1.01263	0.00083	1.0002	0.0045	0.0124	1.01243
299	heust.025/case_12	209.4	1.28E-02	8.76E-02	1.01E-04	1.01107	0.00081	1.0002	0.0045	0.0109	1.01087

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
300	heust.025/case_13	209.2	1.40E-02	8.88E-02	1.13E-04	1.0189	0.00087	1.0009	0.0047	0.0180	1.018
301	heust.025/case_14	205.7	1.92E-02	1.18E-01	1.91E-04	1.01054	0.0008	1.0008	0.0053	0.0097	1.00974
302	heust.025/case_15	206.2	2.05E-02	1.13E-01	1.95E-04	1.0053	0.00093	1.0002	0.0058	0.0051	1.0051
303	heust.025/case_16	199.9	2.55E-02	1.84E-01	3.77E-04	1.01688	0.00084	1	0.0049	0.0169	1.01688
304	heust.025/case_17	200.7	2.99E-02	1.71E-01	4.19E-04	1.00844	0.00098	1	0.0055	0.0084	1.00844
305	heust.025/case_18	201.5	2.90E-02	1.60E-01	3.71E-04	1.00468	0.0009	1	0.0061	0.0047	1.00468
306	heust.025/case_2	218.2	3.42E-03	4.02E-02	1.71E-05	1.0028	0.00108	1.0007	0.0025	0.0021	1.0021
307	heust.025/case_3	217.7	3.45E-03	4.22E-02	1.78E-05	0.99786	0.00116	1.0002	0.0064	-0.0023	0.99766
308	heust.025/case_4	218.0	3.48E-03	4.10E-02	1.77E-05	1.00214	0.00123	1.0003	0.0027	0.0018	1.00184
309	heust.025/case_5	216.2	5.09E-03	4.84E-02	2.78E-05	1.00558	0.00122	1.0013	0.003	0.0043	1.00428
310	heust.025/case_6	217.6	3.35E-03	4.25E-02	1.75E-05	1.01187	0.0008	1.0002	0.0067	0.0117	1.01167
311	heust.025/case_7	216.6	4.89E-03	4.67E-02	2.54E-05	1.01496	0.00075	1.0009	0.0073	0.0141	1.01406
312	heust.025/case_8	216.3	4.89E-03	4.82E-02	2.61E-05	1.01381	0.00099	1	0.0067	0.0138	1.01381
313	heust.025/case_9	214.8	6.54E-03	5.49E-02	3.70E-05	1.00901	0.0009	1.0002	0.0065	0.0088	1.00881
314	heust.027/case_1	211.3	2.96E-03	7.40E-02	1.99E-05	0.99904	0.00038	1	0.0046	-0.0010	0.99904
315	heust.027/case_2	211.2	2.82E-03	7.48E-02	2.05E-05	0.9998	0.00045	1	0.0043	-0.0002	0.9998
316	heust.027/case_3	211.1	2.63E-03	7.50E-02	1.87E-05	0.99996	0.00039	1	0.0037	0.0000	0.99996
317	heust.027/case_4	211.1	2.77E-03	7.53E-02	2.00E-05	1.00134	0.00042	1	0.0037	0.0013	1.00134
318	heust.027/case_5	211.0	2.93E-03	7.56E-02	2.15E-05	0.99915	0.00038	1	0.0044	-0.0009	0.99915
319	heust.027/case_6	211.2	2.73E-03	7.46E-02	1.88E-05	0.99406	0.00037	1	0.0043	-0.0059	0.99406
320	heust.027/case_7	211.2	8.21E-03	7.47E-02	5.91E-05	1.00159	0.00129	1	0.0038	0.0016	1.00159
321	heust.027/case_8	211.2	8.33E-03	7.47E-02	5.91E-05	1.00216	0.00129	1	0.0035	0.0022	1.00216
322	heust.027/case_9	211.2	2.79E-03	7.48E-02	2.06E-05	1.00001	0.00037	1	0.0039	0.0000	1.00001
323	heust.028/hst028a	216.6	4.72E-03	4.68E-02	2.61E-05	0.99816	0.00115	1	0.0023	-0.0018	0.99816
324	heust.028/hst028b	216.4	5.29E-03	4.73E-02	2.69E-05	0.999	0.00113	1	0.0034	-0.0010	0.999
325	heust.028/hst028c	216.5	4.88E-03	4.69E-02	2.63E-05	0.99857	0.00125	1	0.0026	-0.0014	0.99857
326	heust.028/hst028d	216.4	5.09E-03	4.73E-02	2.64E-05	1.00006	0.00116	1	0.0028	0.0001	1.00006

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
327	heust.028/hst028e	216.5	4.78E-03	4.70E-02	2.57E-05	0.99521	0.00109	1	0.0031	-0.0048	0.99521
328	heust.028/hst028g	216.4	5.00E-03	4.74E-02	2.64E-05	0.99818	0.00117	1	0.0023	-0.0018	0.99818
329	heust.028/hst028h	216.5	4.47E-03	4.72E-02	2.47E-05	0.99884	0.00111	1	0.0038	-0.0012	0.99884
330	heust.028/hst028i	216.4	4.79E-03	4.74E-02	2.69E-05	0.99968	0.00107	1	0.0027	-0.0003	0.99968
331	heust.028/hst028j	203.4	1.39E-02	1.45E-01	1.71E-04	0.99678	0.0012	1	0.0049	-0.0032	0.99678
332	heust.028/hst028k	203.2	1.54E-02	1.47E-01	1.88E-04	0.99533	0.00116	1	0.0053	-0.0047	0.99533
333	heust.028/hst028l	203.3	1.41E-02	1.46E-01	1.78E-04	0.9986	0.00129	1	0.0051	-0.0014	0.9986
334	heust.028/hst028m	203.0	1.46E-02	1.49E-01	1.91E-04	0.99563	0.00119	1	0.0046	-0.0044	0.99563
335	heust.028/hst028n	203.0	1.50E-02	1.49E-01	1.83E-04	0.99822	0.00125	1	0.0058	-0.0018	0.99822
336	heust.028/hst028p	202.8	1.46E-02	1.52E-01	1.87E-04	0.9955	0.00113	1	0.0046	-0.0045	0.9955
337	heust.028/hst028q	202.9	1.37E-02	1.51E-01	1.70E-04	1.00355	0.00129	1	0.0064	0.0035	1.00355
338	heust.028/hst028r	202.7	1.54E-02	1.53E-01	1.95E-04	0.99966	0.00112	1	0.0052	-0.0003	0.99966
339	heust.028/hst028s	202.7	1.44E-02	1.53E-01	1.83E-04	0.99623	0.00122	1	0.0066	-0.0038	0.99623
340	heust.028/hst028u	202.6	1.50E-02	1.55E-01	1.96E-04	0.99754	0.00142	1	0.006	-0.0025	0.99754
341	heust.029/hst029a	202.3	1.51E-02	1.58E-01	1.96E-04	0.99819	0.00142	1	0.0066	-0.0018	0.99819
342	heust.029/hst029b	202.3	1.53E-02	1.57E-01	1.97E-04	1.0052	0.00119	1	0.0058	0.0052	1.0052
343	heust.029/hst029c	202.1	1.56E-02	1.60E-01	2.04E-04	0.99533	0.00114	1	0.0068	-0.0047	0.99533
344	heust.029/hst029d	201.5	1.71E-02	1.67E-01	2.33E-04	0.99207	0.00115	1	0.0074	-0.0079	0.99207
345	heust.029/hst029e	201.3	1.56E-02	1.70E-01	2.18E-04	0.99916	0.00133	1	0.0067	-0.0008	0.99916
346	heust.029/hst029g	201.3	1.67E-02	1.70E-01	2.33E-04	0.9992	0.00124	1	0.0065	-0.0008	0.9992
347	heust.029/hst029h	201.4	1.51E-02	1.68E-01	2.09E-04	1.00176	0.00133	1	0.0063	0.0018	1.00176
348	heust.030/hst030a	216.4	5.05E-03	4.74E-02	2.68E-05	0.999	0.00108	1	0.0039	-0.0010	0.999
349	heust.030/hst030b	216.2	5.10E-03	4.81E-02	2.71E-05	1.00047	0.00117	1	0.0032	0.0005	1.00047
350	heust.030/hst030c	216.1	5.10E-03	4.84E-02	2.73E-05	0.99873	0.00115	1	0.0031	-0.0013	0.99873
351	heust.030/hst030d	202.2	1.56E-02	1.59E-01	2.10E-04	1.00129	0.00116	1	0.0064	0.0013	1.00129
352	heust.030/hst030e	202.1	1.54E-02	1.60E-01	1.99E-04	0.99798	0.00112	1	0.0058	-0.0020	0.99798
353	heust.030/hst030g	202.0	1.51E-02	1.61E-01	1.99E-04	0.99864	0.00113	1	0.0059	-0.0014	0.99864

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
354	heust.030/hst030h	201.6	1.47E-02	1.66E-01	2.06E-04	0.99885	0.00118	1	0.0064	-0.0011	0.99885
355	heust.031/hst031a	201.7	1.60E-02	1.64E-01	2.13E-04	0.99762	0.00116	1	0.0046	-0.0024	0.99762
356	heust.031/hst031b	200.7	1.70E-02	1.75E-01	2.41E-04	0.99886	0.00114	1	0.0058	-0.0011	0.99886
357	heust.031/hst031c	201.2	1.64E-02	1.70E-01	2.33E-04	0.99885	0.00121	1	0.0058	-0.0011	0.99885
358	heust.031/hst031d	199.7	1.78E-02	1.90E-01	2.73E-04	0.99486	0.0011	1	0.0068	-0.0051	0.99486
359	heust.032/hst032b	221.1	1.31E-03	3.07E-02	6.94E-06	1.00101	0.00066	1.0015	0.0026	-0.0005	0.99951
360	heust.033-simple/case_02a	193.6	1.95E-02	3.10E-01	4.77E-04	1.00023	0.00118	0.9979	0.0112	0.0023	1.00233
361	heust.033-simple/case_02b	193.3	1.96E-02	3.18E-01	4.90E-04	1	0.00128	1	0.0109	0.0000	1
362	heust.033-simple/case_02c	193.1	1.91E-02	3.23E-01	4.76E-04	0.99873	0.00099	0.9979	0.0067	0.0008	1.00083
363	heust.033-simple/case_03a	194.3	1.81E-02	2.94E-01	4.16E-04	0.99942	0.00111	0.9942	0.0115	0.0052	1.00522
364	heust.033-simple/case_03b	194.4	1.80E-02	2.93E-01	4.22E-04	1.00393	0.00111	0.9979	0.0112	0.0060	1.00603
365	heust.033-simple/case_03c	195.2	1.86E-02	2.74E-01	4.00E-04	1.01165	0.00097	0.9979	0.0072	0.0137	1.01375
366	heust.033-simple/case_04a	193.5	1.89E-02	3.12E-01	4.71E-04	1.00245	0.00107	0.9942	0.0115	0.0083	1.00825
367	heust.033-simple/case_04b	193.2	1.91E-02	3.19E-01	4.79E-04	1.00806	0.00112	0.9979	0.0112	0.0102	1.01016
368	heust.033-simple/case_05a	193.6	1.93E-02	3.10E-01	4.74E-04	1.00832	0.00112	0.9942	0.0112	0.0141	1.01412
369	heust.033-simple/case_05b	193.3	1.87E-02	3.18E-01	4.66E-04	1.00748	0.00125	1	0.0109	0.0075	1.00748
370	heust.033-simple/case_06a	193.6	1.85E-02	3.10E-01	4.59E-04	1.00413	0.00114	0.9942	0.0112	0.0099	1.00993
371	heust.033-simple/case_06b	193.3	1.97E-02	3.17E-01	4.94E-04	1.00926	0.00121	1	0.0109	0.0093	1.00926
372	heust.033-simple/case_07a	193.7	1.94E-02	3.09E-01	4.68E-04	1.00075	0.00119	0.9942	0.0112	0.0066	1.00655
373	heust.033-simple/case_07b	193.4	1.81E-02	3.15E-01	4.38E-04	1.00375	0.00116	1	0.0109	0.0037	1.00375
374	heust.033-simple/case_08a	193.5	1.95E-02	3.13E-01	4.73E-04	1.00001	0.00114	0.9942	0.0112	0.0058	1.00581
375	heust.033-simple/case_08b	193.2	1.85E-02	3.19E-01	4.72E-04	1.00652	0.00109	1	0.0109	0.0065	1.00652
376	heust.033-simple/case_09a	193.7	1.96E-02	3.09E-01	4.78E-04	0.99698	0.00122	0.9942	0.0112	0.0028	1.00278
377	heust.033-simple/case_09b	193.4	1.85E-02	3.15E-01	4.58E-04	0.99746	0.00107	1	0.0109	-0.0025	0.99746
378	heust.033-simple/case_09c	193.8	1.93E-02	3.06E-01	4.55E-04	0.99457	0.00111	0.9979	0.0105	-0.0033	0.99667
379	heust.033-simple/case_10a	194.3	1.87E-02	2.95E-01	4.36E-04	1.00075	0.00118	0.9942	0.0115	0.0066	1.00655
380	heust.033-simple/case_10c	195.1	1.91E-02	2.77E-01	4.05E-04	1.00272	0.00105	0.9979	0.0072	0.0048	1.00482

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
381	heust.033-simple/case_10d	194.1	2.07E-02	3.00E-01	4.84E-04	0.99377	0.00117	0.9979	0.0106	-0.0041	0.99587
382	heust.033-simple/case_11a	194.5	1.86E-02	2.90E-01	4.26E-04	0.99748	0.00106	0.9942	0.0112	0.0033	1.00328
383	heust.033-simple/case_11b	194.7	1.84E-02	2.87E-01	4.13E-04	0.99987	0.00124	0.9979	0.0109	0.0020	1.00197
384	heust.033-simple/case_12a	193.9	1.80E-02	3.05E-01	4.30E-04	0.99929	0.0011	0.9942	0.0112	0.0051	1.00509
385	heust.033-simple/case_12b	193.8	1.89E-02	3.08E-01	4.61E-04	1.00059	0.00121	1	0.0109	0.0006	1.00059
386	heust.035/hst035a	219.1	2.86E-03	3.70E-02	1.49E-05	1.0043	0.00087	1	0.0031	0.0043	1.0043
387	heust.035/hst035b	219.0	2.99E-03	3.72E-02	1.44E-05	1.00552	0.00092	1	0.0032	0.0055	1.00552
388	heust.035/hst035c	219.0	2.97E-03	3.72E-02	1.44E-05	1.00655	0.00086	1	0.003	0.0066	1.00655
389	heust.035/hst035d	219.1	2.87E-03	3.70E-02	1.39E-05	1.00663	0.00088	1	0.003	0.0066	1.00663
390	heust.035/hst035e	216.0	5.33E-03	4.89E-02	2.96E-05	1.00477	0.00103	1	0.0033	0.0048	1.00477
391	heust.035/hst035g	215.9	5.31E-03	4.95E-02	3.01E-05	1.0071	0.00106	1	0.0029	0.0071	1.0071
392	heust.035/hst035h	210.4	8.86E-03	8.02E-02	6.61E-05	1.00413	0.00109	1	0.0035	0.0041	1.00413
393	heust.035/hst035i	209.9	9.56E-03	8.35E-02	7.51E-05	1.00207	0.00132	1	0.0038	0.0021	1.00207
394	heust.035/hst035j	210.0	9.83E-03	8.25E-02	7.33E-05	1.00344	0.00118	1	0.0041	0.0034	1.00344
395	heust.036/hst036a	214.6	6.02E-03	5.56E-02	3.66E-05	0.99619	0.00112	0.9974	0.0045	-0.0012	0.99879
396	heust.036/hst036b	214.1	6.36E-03	5.78E-02	3.74E-05	1.00008	0.00124	0.9979	0.0039	0.0022	1.00218
397	heust.036/hst036c	213.5	7.22E-03	6.05E-02	4.32E-05	0.99706	0.00126	0.9993	0.0044	-0.0022	0.99776
398	heust.036/hst036d	213.0	7.46E-03	6.28E-02	4.57E-05	0.99964	0.00109	1	0.0062	-0.0004	0.99964
399	heust.037/hst037a	218.8	3.02E-03	3.79E-02	1.47E-05	1.01151	0.00105	0.998	0.0034	0.0135	1.01351
400	heust.037/hst037b	218.5	3.87E-03	3.89E-02	1.67E-05	1.00335	0.00096	0.999	0.0035	0.0043	1.00435
401	heust.037/hst037c	217.3	4.04E-03	4.38E-02	2.22E-05	1.00809	0.00105	0.997	0.0042	0.0111	1.01109
402	heust.037/hst037d	216.9	4.92E-03	4.50E-02	2.42E-05	1.00894	0.00104	0.998	0.0035	0.0109	1.01094
403	heust.037/hst037e	216.8	5.50E-03	4.55E-02	2.63E-05	1.00635	0.00104	0.998	0.0042	0.0084	1.00835
404	heust.037/hst037g	215.6	5.51E-03	5.08E-02	3.04E-05	1.01374	0.00129	0.996	0.0051	0.0177	1.01774
405	heust.037/hst037h	215.2	6.29E-03	5.24E-02	3.37E-05	1.01342	0.00115	0.998	0.0034	0.0154	1.01542
406	heust.037/hst037i	215.1	6.85E-03	5.31E-02	3.61E-05	1.00632	0.00126	0.998	0.004	0.0083	1.00832
407	heust.037/hst037j	214.8	7.97E-03	5.40E-02	3.84E-05	1.00572	0.00127	0.998	0.0047	0.0077	1.00772

Results for Volume 2: HEU Systems, Rev. 0

N	Case	AFG	sigma	EALCF(ev)	sigma	k_calc HEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU0*
	Maximum	221.1	8.64E-02	9.57E+05	1.64E+03	1.03006	0.00159	1.006	0.0126	0.03006	1.03006
	Average	168.5	2.25E-02	8.66E+04	1.47E+02	1.001147	0.00109	0.9994	0.0044	0.00173	1.00173
	Minimum	24.3	1.31E-03	3.07E-02	6.94E-06	0.96808	0.00037	0.9826	0	-0.02034	0.97966

Results for Volume 2: HEU Systems, Rev. 1

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	Sigma	k_calc HEU1	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU1*	Notes
1		hci003-01	2.53	2.11E-04	63.5	5.24E-02	7.99E+03	4.11E+01	1.00878	0.00096	1	0.0057	0.00878	1.00878	
2		hci003-02	2.51	2.22E-04	69.2	5.72E-02	4.27E+03	2.31E+01	1.01087	0.00105	1	0.0061	0.01087	1.01087	
3		hci003-03	2.51	2.04E-04	69.3	5.38E-02	4.27E+03	2.18E+01	1.01367	0.00103	1	0.0056	0.01367	1.01367	
4		hci003-04	2.51	1.91E-04	67.1	5.17E-02	5.41E+03	2.72E+01	1.00261	0.00108	1	0.0055	0.00261	1.00261	
5		hci003-05	2.50	1.05E-04	70.3	4.00E-02	3.74E+03	1.27E+01	1.00415	0.00111	1	0.0047	0.00415	1.00415	
6		hci003-06	2.51	1.44E-04	66.1	4.75E-02	5.97E+03	2.55E+01	1.0004	0.00103	1	0.0047	0.0004	1.0004	
7		hci003-07	2.51	1.34E-04	66.2	4.17E-02	5.87E+03	2.20E+01	0.99801	0.00096	1	0.005	-0.00199	0.99801	
8		hci004	2.44	7.38E-06	97.8	1.81E-02	1.39E+02	1.46E-01	1.02231	0.00021	1	0.004	0.02231	1.02231	k-inf
9		hci005-07	2.45	3.21E-05	63.8	1.74E-02	5.09E+03	1.09E+01	0.9712	0.00049	1.032	0.004	-0.0608	0.9392	k-inf
10		hci005-09	2.45	2.79E-05	66.5	1.55E-02	3.21E+03	5.93E+00	1.01827	0.0004	1.05	0.008	-0.03173	0.96827	k-inf
11		hci005-15	2.45	2.81E-05	60.7	1.36E-02	6.50E+03	1.24E+01	**0.92044**	0.00043	1.064	0.018	-0.14356	**0.85644**	k-inf
12		hci005-16	2.45	2.94E-05	64.1	1.64E-02	4.18E+03	7.97E+00	0.95005	0.00042	0.997	0.013	-0.04695	0.95305	k-inf
13		hcm001-1	2.45	4.06E-05	192.8	4.51E-02	3.80E-01	1.25E-03	1.00526	0.00099	1	0.0059	0.00526	1.00526	

Results for Volume 2: HEU Systems, Rev. 1

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	Sigma	k_calc HEU1	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU1*	Notes
14		hcm001-5	2.52	1.49E-04	94.0	8.86E-02	1.57E+03	1.16E+01	0.99922	0.00097	0.9985	0.0056	0.00072	1.00072	
15		hct017-01	2.44	2.20E-06	219.8	1.12E-02	3.82E-02	5.08E-05	1.01264	0.00117	1	0.0069	0.01264	1.01264	
16		hct017-02	2.44	2.56E-06	216.2	1.68E-02	5.23E-02	8.22E-05	1.00185	0.00098	1	0.0069	0.00185	1.00185	
17		hct017-03	2.44	2.47E-06	218.9	1.27E-02	4.11E-02	5.38E-05	1.00868	0.00106	1	0.0069	0.00868	1.00868	
18		hct017-04	2.44	2.16E-06	220.3	1.04E-02	3.65E-02	4.80E-05	1.01006	0.00108	1	0.0069	0.01006	1.01006	
19		hct017-05	2.44	2.20E-06	220.7	8.58E-03	3.52E-02	4.27E-05	1.01265	0.00111	1	0.0069	0.01265	1.01265	
20		hct017-06	2.44	2.17E-06	219.6	1.20E-02	3.89E-02	5.32E-05	1.01208	0.00098	1	0.0069	0.01208	1.01208	
21		hct017-07	2.44	2.40E-06	217.7	1.49E-02	4.57E-02	6.81E-05	1.00656	0.00106	1	0.0069	0.00656	1.00656	
22		hct017-08	2.44	2.24E-06	220.8	9.14E-03	3.46E-02	4.17E-05	1.01685	0.00112	1	0.0069	0.01685	1.01685	
23		hct017-09	2.44	2.40E-06	219.6	1.21E-02	3.86E-02	5.25E-05	1.0088	0.00106	1	0.0069	0.0088	1.0088	
24		hmf015-1	2.61	2.00E-04	24.2	1.21E-02	9.62E+05	1.11E+03	0.99102	0.00089	0.9996	0.0017	-0.00858	0.99142	
25		hmf016-1	2.58	1.96E-04	28.5	2.22E-02	5.89E+05	1.32E+03	0.99981	0.00094	0.9996	0.0018	0.00021	1.00021	
26		hmf016-2	2.58	2.04E-04	27.6	1.85E-02	6.54E+05	1.28E+03	1.00063	0.00086	0.9996	0.0018	0.00103	1.00103	
27		hmf017	2.57	1.80E-04	29.1	1.60E-02	5.50E+05	9.93E+02	0.99593	0.0012	0.9993	0.0014	-0.00337	0.99663	
28		hmf033-1	2.53	1.45E-04	61.9	5.68E-02	1.54E+04	7.85E+01	0.98935	0.00127	0.9991	0.0014	-0.00975	0.99025	
29		hmf033-2	2.51	1.50E-04	92.2	7.81E-02	1.20E+03	7.64E+00	0.99726	0.00102	0.9991	0.0014	-0.00184	0.99816	
30		hmf036-1	2.53	1.68E-04	78.5	7.90E-02	4.41E+03	2.97E+01	0.99108	0.00108	0.9993	0.0015	-0.00822	0.99178	
31		hmf036-2	2.56	1.86E-04	59.0	6.47E-02	2.91E+04	1.65E+02	0.99613	0.00098	0.9993	0.0013	-0.00317	0.99683	
32		hmf037-1	2.53	1.62E-04	88.7	7.92E-02	2.37E+03	1.57E+01	1.00133	0.0009	0.9997	0.0011	0.00163	1.00163	
33		hmf037-2	2.55	1.70E-04	63.9	6.62E-02	1.72E+04	9.78E+01	0.99724	0.00099	0.9997	0.0011	-0.00246	0.99754	
34		hmf038	2.56	3.58E-04	34.7	3.42E-02	2.48E+05	9.55E+02	1.00496	0.00095	0.9999	0.0015	0.00506	1.00506	
35		hmf041-1	2.58	1.84E-04	28.4	1.64E-02	5.91E+05	1.09E+03	1.00383	0.0011	1.0013	0.003	0.00253	1.00253	
36		hmf041-2	2.56	1.63E-04	41.6	5.18E-02	1.52E+05	7.23E+02	1.00269	0.00098	1.0022	0.0043	0.00049	1.00049	
37		hmf041-3	2.59	1.95E-04	25.6	1.39E-02	8.33E+05	1.12E+03	0.99812	0.0011	1.0006	0.0029	-0.00248	0.99752	
38		hmf041-4	2.59	2.02E-04	26.9	1.52E-02	7.13E+05	1.16E+03	1.00172	0.00098	1.0006	0.0025	0.00112	1.00112	
39		hmf041-5	2.58	1.82E-04	28.7	2.02E-02	5.70E+05	1.23E+03	0.9967	0.00088	1.0006	0.0031	-0.0039	0.9961	
40		hmf041-6	2.58	1.81E-04	31.3	3.02E-02	4.35E+05	1.30E+03	0.99885	0.0009	1.0006	0.0045	-0.00175	0.99825	
41		hmf055-1	2.55	1.59E-04	32.0	1.22E-02	4.22E+05	5.41E+02	1.00812	0.00078	0.9955	0.0028	0.01262	1.01262	

Results for Volume 2: HEU Systems, Rev. 1

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	Sigma	k_calc HEU1	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff HEU1*	Notes
42		hmf055-2	2.55	2.45E-04	31.9	1.97E-02	4.25E+05	8.15E+02	1.00983	0.00078	0.9955	0.0028	0.01433	1.01433	assumed same k_bench
43		hmf055-3	2.55	2.42E-04	31.9	1.81E-02	4.23E+05	7.60E+02	1.00433	0.00077	0.9955	0.0028	0.00883	1.00883	assumed same k_bench
44		hmf055-4	2.55	2.73E-04	31.9	2.01E-02	4.25E+05	8.55E+02	0.99685	0.00075	0.9955	0.0028	0.00135	1.00135	assumed same k_bench
45		hmi001	2.46	8.08E-05	51.6	1.60E-02	2.93E+04	6.55E+01	**1.08365**	0.00085	0.9966	0.0026	0.08705	**1.08705**	Iron xs problem
46		hmi006-001	2.47	8.01E-05	64.4	3.19E-02	5.02E+03	1.60E+01	1.00282	0.00112	0.9948	0.0003	0.00802	1.00802	
47		hmi006-002	2.48	9.12E-05	57.5	2.45E-02	1.04E+04	2.91E+01	1.0033	0.00088	0.9981	0.0003	0.0052	1.0052	
48		hmi006-003	2.48	9.20E-05	51.0	1.99E-02	2.43E+04	6.53E+01	1.00681	0.00086	1.0016	0.0003	0.00521	1.00521	
49		hmt001	2.44	2.00E-05	213.4	2.71E-02	7.39E-02	1.66E-04	1.00592	0.00096	1.001	0.006	0.00492	1.00492	
50		hst021-10	2.44	9.01E-06	195.0	2.04E-02	2.82E-01	4.45E-04	1.00828	0.00111	0.9975	0.0054	0.01078	1.01078	
51		hst021-2	2.44	9.12E-06	194.7	1.98E-02	2.89E-01	4.54E-04	1.00604	0.00136	0.9975	0.0054	0.00854	1.00854	
52		hst021-25	2.44	8.80E-06	195.8	2.11E-02	2.65E-01	4.41E-04	1.00624	0.00118	0.9978	0.0054	0.00844	1.00844	
53		hst021-3	2.44	8.79E-06	195.3	2.01E-02	2.76E-01	4.46E-04	1.01108	0.00125	0.9975	0.0054	0.01358	1.01358	
		Maximum	2.61	3.58E-04	2.21E+02	8.86E-02	9.62E+05	1.32E+03	1.08365	0.00136	1.064	0.018	0.08705	1.08705	
		Average	2.50	1.15E-04	9.74E+01	3.01E-02	1.54E+05	3.03E+02	1.00228	0.000952642	1.002	0.004462264	0.000279623	1.000279623	
		Minimum	2.44	2.16E-06	1.23E+01	2.89E-03	3.46E-02	4.17E-05	0.92044	0.00021	0.9948	0.0003	-0.14356	0.85644	

Table 4.3 Results for Intermediate and Mixed Enrichment Uranium Systems (Volume 3) with CSAS25 from SCALE 4.4a and the 238-group Library on the J-5600 (CMODB) Workstation

Results for Volume 3: IEU Systems

									k_calc				Adjusted k-eff	
N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	IEU	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	IEU*	Notes
1		ici001-001	2.47	6.73E-05	39.738	7.50E-03	1.85E+05	1.77E+02	1.00476	0.00035	0.969	0.005	0.0358	1.03576	k-inf
2		ici001-002	2.47	6.76E-05	52.075	2.07E-02	2.66E+04	6.26E+01	1.02029	0.00046	0.980	0.003	0.0403	1.04029	k-inf
3		ici001-003	2.45	5.05E-05	124.130	5.00E-02	5.59E+01	1.96E-01	1.06991	0.00056	1.014	0.006	0.0559	**1.05591**	k-inf
4		ici001-004	2.44	3.29E-05	185.505	3.84E-02	6.83E-01	1.87E-03	0.97726	0.00071	0.964	0.012	0.0133	1.01326	k-inf
5		ict001-01	2.46	4.77E-05	151.897	5.91E-02	7.38E+00	3.01E-02	0.99766	0.00115	1	0.004	-0.0023	0.99766	
6		ict001-02	2.45	3.94E-05	169.336	5.22E-02	2.03E+00	7.32E-03	1.00086	0.00113	1	0.004	0.0009	1.00086	
7		ict001-03	2.45	3.01E-05	185.745	4.30E-02	6.11E-01	1.81E-03	0.99570	0.00111	1	0.004	-0.0043	0.99570	
8		ict001-04	2.44	2.61E-05	197.906	3.32E-02	2.50E-01	5.75E-04	1.00100	0.00118	1	0.004	0.0010	1.00100	
9		ict001-05	2.44	1.88E-05	209.500	2.36E-02	1.03E-01	1.91E-04	1.01458	0.00104	1	0.004	0.0146	1.01458	
10		ict001-06	2.45	3.05E-05	185.682	4.05E-02	6.18E-01	1.77E-03	1.00318	0.00117	1	0.004	0.0032	1.00318	
11		ict001-07	2.45	3.19E-05	185.722	4.14E-02	6.21E-01	1.75E-03	1.00248	0.00109	1	0.004	0.0025	1.00248	
12		ict001-08	2.45	3.46E-05	185.290	4.16E-02	6.48E-01	1.88E-03	0.99951	0.00111	1	0.004	-0.0005	0.99951	
13		ict001-09	2.46	4.21E-05	172.650	5.06E-02	1.67E+00	5.78E-03	1.00676	0.00113	1	0.004	0.0068	1.00676	
14		ict001-10	2.45	3.83E-05	169.467	5.09E-02	2.02E+00	7.02E-03	0.99801	0.00114	1	0.004	-0.0020	0.99801	
15		ict001-11	2.45	3.93E-05	169.606	5.26E-02	1.99E+00	7.03E-03	0.99816	0.00108	1	0.004	-0.0018	0.99816	
16		ict001-12	2.45	3.98E-05	170.004	4.92E-02	1.94E+00	6.55E-03	0.99760	0.00115	1	0.004	-0.0024	0.99760	
17		ict001-13	2.44	2.53E-05	197.984	3.37E-02	2.48E-01	5.96E-04	1.00359	0.00104	1	0.004	0.0036	1.00359	
18		ict001-14	2.44	2.38E-05	197.957	3.19E-02	2.49E-01	5.70E-04	1.00125	0.00109	1	0.004	0.0012	1.00125	
19		ict001-15	2.44	2.42E-05	198.123	3.21E-02	2.46E-01	5.69E-04	1.00192	0.00118	1	0.004	0.0019	1.00192	

Results for Volume 3: IEU Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	k_calc sigma	k_calc IEU	k_calc sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff IEU*	Notes
20		ict001-16	2.44	2.09E-05	205.446	2.53E-02	1.41E-01	2.73E-04	1.00609	0.00115	1	0.004	0.0061	1.00609	
21		ict001-17	2.46	4.92E-05	150.212	5.69E-02	8.15E+00	3.14E-02	0.99447	0.00113	1	0.004	-0.0055	**0.99447**	
22		ict001-18	2.45	3.66E-05	173.839	4.40E-02	1.47E+00	4.40E-03	0.99970	0.00121	1	0.004	-0.0003	0.99970	
23		ict001-19	2.44	2.27E-05	203.398	2.79E-02	1.65E-01	3.51E-04	1.00515	0.00111	1	0.004	0.0051	1.00515	
24		ict001-20	2.45	4.12E-05	168.133	5.22E-02	2.19E+00	7.83E-03	1.00337	0.00130	1	0.004	0.0034	1.00337	
25		ict001-21	2.46	5.16E-05	150.237	6.26E-02	8.08E+00	3.45E-02	0.99932	0.00093	1	0.004	-0.0007	0.99932	
26		ict001-22	2.46	4.76E-05	151.174	5.36E-02	7.49E+00	2.71E-02	0.99765	0.00116	1	0.004	-0.0023	0.99765	
27		ict001-23	2.45	3.52E-05	174.063	4.60E-02	1.44E+00	4.53E-03	0.99591	0.00129	1	0.004	-0.0041	0.99591	
28		ict001-24	2.45	3.65E-05	173.308	4.47E-02	1.52E+00	4.64E-03	1.00163	0.00119	1	0.004	0.0016	1.00163	
29		ict001-25	2.44	2.19E-05	203.081	2.93E-02	1.69E-01	3.70E-04	1.00502	0.00127	1	0.004	0.0050	1.00502	
30		ict001-26	2.44	2.00E-05	205.413	2.71E-02	1.41E-01	2.86E-04	1.00799	0.00105	1	0.004	0.0080	1.00799	
31		ict001-27	2.44	2.03E-05	205.570	2.40E-02	1.39E-01	2.61E-04	1.00810	0.00115	1	0.004	0.0081	1.00810	
32		ict001-28	2.45	3.97E-05	169.749	5.16E-02	1.98E+00	7.06E-03	1.00742	0.00106	1	0.004	0.0074	1.00742	
33		ict001-29	2.45	3.87E-05	170.698	4.97E-02	1.84E+00	6.21E-03	1.00360	0.00104	1	0.004	0.0036	1.00360	
34		ict003-01	2.44	6.18E-06	211.878	9.51E-03	7.96E-02	8.19E-05	1.00224	0.00110	1.0006	0.0056	0.0016	1.00164	
35		ict003-02	2.44	6.35E-06	211.883	8.95E-03	7.96E-02	7.67E-05	1.00557	0.00125	1.0046	0.0056	0.0010	1.00097	
36		imf001-01i	2.59	1.95E-04	26.211	1.25E-02	8.08E+05	9.78E+02	1.00078	0.00106	0.9989	0.0009	0.0019	1.00188	
37		imf001-02i	2.59	1.99E-04	26.180	1.28E-02	8.10E+05	1.00E+03	1.00127	0.00085	0.9997	0.0009	0.0016	1.00157	
38		imf001-03i	2.59	1.90E-04	27.148	1.25E-02	7.39E+05	9.03E+02	1.00404	0.00120	0.9993	0.0003	0.0047	1.00474	
39		imf001-04i	2.59	1.93E-04	27.141	1.25E-02	7.40E+05	9.18E+02	1.00471	0.00100	1.0002	0.0003	0.0045	1.00451	
40		imf002-001	2.58	2.02E-04	29.765	1.24E-02	5.58E+05	6.99E+02	1.00826	0.00080	1	0.003	0.0083	1.00826	
41		imf003-01	2.58	1.91E-04	27.603	1.18E-02	7.09E+05	8.38E+02	1.00472	0.00091	1	0.0017	0.0047	1.00472	
42		imf004-01	2.58	1.89E-04	28.188	1.23E-02	6.66E+05	8.16E+02	1.00933	0.00083	1	0.003	0.0093	1.00933	
43		imf005-001	2.57	1.69E-04	28.330	1.16E-02	6.59E+05	7.77E+02	1.01041	0.00082	1	0.0021	0.0104	1.01041	
44		imf006-001	2.58	1.87E-04	28.337	1.19E-02	6.59E+05	7.91E+02	0.99583	0.00083	1	0.0023	-0.0042	0.99583	
45		imf007-001	2.57	2.30E-04	30.725	1.51E-02	4.93E+05	7.36E+02	1.01727	0.00074	1.0045	0.0007	0.0128	1.01277	
46		imf008-001	2.59	1.86E-04	27.661	1.14E-02	7.03E+05	8.07E+02	1.00816	0.00084	1	0.0018	0.0082	1.00816	
47		imf009-001	2.55	1.66E-04	68.986	7.62E-02	1.53E+04	9.97E+01	1.01084	0.00095	1	0.0053	0.0108	1.01084	

Results for Volume 3: IEU Systems

N	Category	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc IEU	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff IEU*	Notes
48		imf010-001	2.56	1.76E-04	32.291	1.08E-02	4.12E+05	4.78E+02	1.00629	0.00071	0.9954	0.0024	0.0109	1.01089	
49		imf012-001	2.55	1.42E-04	33.203	1.09E-02	3.70E+05	4.48E+02	1.00876	0.00077	1.0007	0.0027	0.0081	1.00806	
50		imf014-092	2.54	1.38E-04	34.746	9.41E-03	3.21E+05	3.34E+02	1.01409	0.00063	0.9952	0.0022	0.0189	1.01889	
51		imf014-093	2.52	1.06E-04	36.517	8.08E-03	2.66E+05	2.48E+02	1.01036	0.00070	0.9916	0.0022	0.0188	1.01876	
		Maximum	2.59	0.000230428	211.883	0.0762186	8.10E+05	1.00E+03	1.06991	0.0013	1.0140	0.0120	0.0559	1.0559	
		Average	2.49	7.97615E-05	126.2312333	0.030845963	1.79E+05	2.18E+02	1.00498	0.000996667	0.9984	0.0036	0.0066	1.0066	
		Minimum	2.44	6.17612E-06	19.0597	0.00525341	7.96E-02	7.67E-05	0.97726	0.00035	0.9640	0.0003	-0.0055	0.9945	

Table 4.4 Results for Low Enriched Uranium Systems (Volume 4) with CSAS25 from SCALE 4.4a and the 238-group Library on the J-5600 (CMODB) Workstation

Results for Volume 4: LEU Systems, Rev. 0

N	Case	AFG	sigma	AELCF(ev)	sigma	k_calc LEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU0*
1	leuct.001/case_1	208.739	2.05E-02	9.88E-02	1.86E-04	0.99462	0.0008	0.9998	0.0031	-0.00518	0.99482
2	leuct.001/case_2	208.878	2.02E-02	9.77E-02	1.81E-04	0.99464	0.00079	0.9998	0.0031	-0.00516	0.99484
3	leuct.001/case_3	208.981	2.01E-02	9.68E-02	1.76E-04	0.99251	0.00088	0.9998	0.0031	-0.00729	0.99271
4	leuct.001/case_4	208.872	2.12E-02	9.78E-02	1.89E-04	0.99282	0.0009	0.9998	0.0031	-0.00698	0.99302
5	leuct.001/case_5	209.069	1.99E-02	9.61E-02	1.72E-04	0.99198	0.0009	0.9998	0.0031	-0.00782	0.99218
6	leuct.001/case_6	208.902	1.96E-02	9.76E-02	1.75E-04	0.9927	0.00095	0.9998	0.0031	-0.0071	0.9929
7	leuct.001/case_7	209.155	1.99E-02	9.54E-02	1.74E-04	0.99302	0.00094	0.9998	0.0031	-0.00678	0.99322

Results for Volume 4: LEU Systems, Rev. 0

N	Case	AFG	sigma	AELCF(ev)	sigma	k_calc LEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU0*
8	leuct.001/case_8	209.025	2.05E-02	9.64E-02	1.79E-04	0.99317	0.00085	0.9998	0.0031	-0.00663	0.99337
9	leuct.002/case_1	207.414	2.22E-02	1.16E-01	2.26E-04	0.99313	0.00095	0.9997	0.002	-0.00657	0.99343
10	leuct.002/case_2	207.449	2.17E-02	1.15E-01	2.24E-04	0.99659	0.001	0.9997	0.002	-0.00311	0.99689
11	leuct.002/case_3	207.42	2.18E-02	1.16E-01	2.20E-04	0.99443	0.00089	0.9997	0.002	-0.00527	0.99473
12	leuct.002/case_4	207.584	2.14E-02	1.14E-01	2.15E-04	0.99222	0.00101	0.9997	0.002	-0.00748	0.99252
13	leuct.002/case_5	207.736	2.31E-02	1.13E-01	2.26E-04	0.99262	0.00115	0.9997	0.002	-0.00708	0.99292
14	leuct.003/case_1	201.843	2.61E-02	1.78E-01	4.02E-04	0.98246	0.00093	1	0.0039	-0.01754	0.98246
15	leuct.003/case_10	202.605	2.53E-02	1.67E-01	3.65E-04	0.97622	0.00091	1	0.0039	-0.02378	0.97622
16	leuct.003/case_11	203.892	2.59E-02	1.50E-01	3.36E-04	0.97878	0.00097	1	0.0039	-0.02122	0.97878
17	leuct.003/case_12	203.52	2.65E-02	1.55E-01	3.64E-04	0.97602	0.0009	1	0.0039	-0.02398	0.97602
18	leuct.003/case_13	203.521	2.65E-02	1.54E-01	3.58E-04	0.98346	0.00092	1	0.0039	-0.01654	0.98346
19	leuct.003/case_14	203.57	2.53E-02	1.54E-01	3.50E-04	0.97766	0.0009	1	0.0039	-0.02234	0.97766
20	leuct.003/case_15	203.515	2.50E-02	1.55E-01	3.43E-04	0.98011	0.00096	1	0.0039	-0.01989	0.98011
21	leuct.003/case_16	203.278	2.49E-02	1.58E-01	3.49E-04	0.98168	0.00093	1	0.0039	-0.01832	0.98168
22	leuct.003/case_17	203.17	2.73E-02	1.59E-01	3.82E-04	0.97774	0.00111	1	0.0039	-0.02226	0.97774
23	leuct.003/case_18	203.035	2.65E-02	1.61E-01	3.77E-04	0.97974	0.00093	1	0.0039	-0.02026	0.97974
24	leuct.003/case_19	202.946	2.62E-02	1.62E-01	3.74E-04	0.97964	0.00103	1	0.0039	-0.02036	0.97964
25	leuct.003/case_2	201.794	2.52E-02	1.78E-01	3.96E-04	0.98209	0.00088	1	0.0039	-0.01791	0.98209
26	leuct.003/case_20	202.201	2.70E-02	1.72E-01	4.05E-04	0.98077	0.00094	1	0.0039	-0.01923	0.98077
27	leuct.003/case_21	202.515	2.62E-02	1.68E-01	3.86E-04	0.97881	0.00092	1	0.0039	-0.02119	0.97881
28	leuct.003/case_22	202.922	2.57E-02	1.62E-01	3.63E-04	0.98988	0.00098	1	0.0039	-0.01012	0.98988
29	leuct.003/case_3	201.817	2.62E-02	1.78E-01	4.17E-04	0.98458	0.00081	1	0.0039	-0.01542	0.98458
30	leuct.003/case_4	201.75	2.67E-02	1.79E-01	4.20E-04	0.98333	0.00079	1	0.0039	-0.01667	0.98333
31	leuct.003/case_5	201.787	2.71E-02	1.79E-01	4.28E-04	0.98229	0.00084	1	0.0039	-0.01771	0.98229
32	leuct.003/case_6	203.53	2.50E-02	1.54E-01	3.45E-04	0.98089	0.00102	1	0.0039	-0.01911	0.98089
33	leuct.003/case_7	202.748	2.62E-02	1.65E-01	3.80E-04	0.98501	0.00086	1	0.0039	-0.01499	0.98501
34	leuct.003/case_8	203.281	2.62E-02	1.58E-01	3.62E-04	0.98575	0.00091	1	0.0039	-0.01425	0.98575
35	leuct.003/case_9	203.183	2.45E-02	1.59E-01	3.44E-04	0.97818	0.00101	1	0.0039	-0.02182	0.97818

Results for Volume 4: LEU Systems, Rev. 0

N	Case	AFG	sigma	AELCF(ev)	sigma	k_calc LEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU0*
36	leuct.004/case_1	195.731	3.16E-02	3.01E-01	7.80E-04	0.986	0.00105	0.9998	0.0033	-0.0138	0.9862
37	leuct.004/case_10	196.503	3.12E-02	2.82E-01	7.24E-04	0.98916	0.00105	0.9998	0.0035	-0.01064	0.98936
38	leuct.004/case_11	199.831	2.78E-02	2.16E-01	5.09E-04	0.98122	0.00097	0.9998	0.0035	-0.01858	0.98142
39	leuct.004/case_12	198.948	2.96E-02	2.32E-01	5.82E-04	0.97513	0.00101	0.9998	0.0035	-0.02467	0.97533
40	leuct.004/case_13	198.402	3.03E-02	2.43E-01	6.06E-04	0.98301	0.00107	0.9998	0.0035	-0.01679	0.98321
41	leuct.004/case_14	198.455	3.04E-02	2.42E-01	6.15E-04	0.98267	0.00111	0.9998	0.0035	-0.01713	0.98287
42	leuct.004/case_15	198.481	2.96E-02	2.41E-01	5.92E-04	0.9829	0.00103	0.9998	0.0035	-0.0169	0.9831
43	leuct.004/case_16	198.331	2.91E-02	2.44E-01	5.99E-04	0.98202	0.00123	0.9998	0.0035	-0.01778	0.98222
44	leuct.004/case_17	198.253	3.00E-02	2.46E-01	6.20E-04	0.9848	0.00085	0.9998	0.0035	-0.015	0.985
45	leuct.004/case_18	198.176	3.05E-02	2.47E-01	6.37E-04	0.9839	0.00104	0.9998	0.0035	-0.0159	0.9841
46	leuct.004/case_19	197.977	2.93E-02	2.51E-01	6.13E-04	0.98182	0.001	0.9998	0.0035	-0.01798	0.98202
47	leuct.004/case_2	195.667	2.99E-02	3.02E-01	7.56E-04	0.98517	0.00119	0.9998	0.0033	-0.01463	0.98537
48	leuct.004/case_20	199.098	2.96E-02	2.30E-01	5.64E-04	0.97991	0.00115	0.9998	0.0035	-0.01989	0.98011
49	leuct.004/case_3	195.706	3.11E-02	3.01E-01	7.76E-04	0.98662	0.00094	0.9998	0.0033	-0.01318	0.98682
50	leuct.004/case_4	195.664	3.19E-02	3.02E-01	8.06E-04	0.98845	0.00096	0.9998	0.0033	-0.01135	0.98865
51	leuct.004/case_5	200.558	2.70E-02	2.04E-01	4.60E-04	0.9867	0.001	0.9998	0.0033	-0.0131	0.9869
52	leuct.004/case_6	198.361	3.03E-02	2.44E-01	6.17E-04	0.98524	0.00098	0.9998	0.0033	-0.01456	0.98544
53	leuct.004/case_7	200.225	2.80E-02	2.10E-01	4.94E-04	0.98555	0.00111	0.9998	0.0033	-0.01425	0.98575
54	leuct.004/case_8	198.055	2.97E-02	2.50E-01	6.19E-04	0.98342	0.001	0.9998	0.0035	-0.01638	0.98362
55	leuct.004/case_9	196.323	3.20E-02	2.87E-01	7.51E-04	0.98495	0.00098	0.9998	0.0035	-0.01485	0.98515
56	leuct.016/case_01	208.92	2.12E-02	9.73E-02	1.87E-04	0.99214	0.00094	1	0.0031	-0.00786	0.99214
57	leuct.016/case_02	208.935	2.04E-02	9.72E-02	1.84E-04	0.99191	0.00095	1	0.0031	-0.00809	0.99191
58	leuct.016/case_03	208.875	1.99E-02	9.76E-02	1.79E-04	0.99225	0.00091	1	0.0031	-0.00775	0.99225
59	leuct.016/case_04	208.877	2.04E-02	9.77E-02	1.75E-04	0.99311	0.00096	1	0.0031	-0.00689	0.99311
60	leuct.016/case_05	208.923	1.99E-02	9.74E-02	1.77E-04	0.99348	0.00081	1	0.0031	-0.00652	0.99348
61	leuct.016/case_06	208.824	2.13E-02	9.82E-02	1.88E-04	0.9941	0.00092	1	0.0031	-0.0059	0.9941
62	leuct.016/case_07	208.877	2.15E-02	9.76E-02	1.93E-04	0.99436	0.00093	1	0.0031	-0.00564	0.99436
63	leuct.016/case_08	208.736	2.04E-02	9.88E-02	1.86E-04	0.99392	0.00083	1	0.0031	-0.00608	0.99392

Results for Volume 4: LEU Systems, Rev. 0

N	Case	AFG	sigma	AELCF(ev)	sigma	k_calc LEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU0*
64	leuct.016/case_09	208.831	2.07E-02	9.80E-02	1.82E-04	0.99357	0.00082	1	0.0031	-0.00643	0.99357
65	leuct.016/case_10	208.707	1.92E-02	9.91E-02	1.73E-04	0.99251	0.00092	1	0.0031	-0.00749	0.99251
66	leuct.016/case_11	208.8	2.16E-02	9.83E-02	1.94E-04	0.99262	0.00098	1	0.0031	-0.00738	0.99262
67	leuct.016/case_12	208.639	2.10E-02	9.96E-02	1.92E-04	0.99355	0.00107	1	0.0031	-0.00645	0.99355
68	leuct.016/case_13	208.757	2.04E-02	9.87E-02	1.79E-04	0.99146	0.00084	1	0.0031	-0.00854	0.99146
69	leuct.016/case_14	208.634	2.06E-02	9.97E-02	1.90E-04	0.99467	0.00092	1	0.0031	-0.00533	0.99467
70	leuct.016/case_15	208.872	2.05E-02	9.78E-02	1.81E-04	0.99424	0.00092	1	0.0031	-0.00576	0.99424
71	leuct.016/case_16	208.879	1.95E-02	9.76E-02	1.74E-04	0.9911	0.00082	1	0.0031	-0.0089	0.9911
72	leuct.016/case_17	208.906	2.03E-02	9.74E-02	1.82E-04	0.99271	0.00089	1	0.0031	-0.00729	0.99271
73	leuct.016/case_18	208.873	1.97E-02	9.76E-02	1.76E-04	0.99534	0.00092	1	0.0031	-0.00466	0.99534
74	leuct.016/case_19	208.905	2.03E-02	9.76E-02	1.81E-04	0.99452	0.00087	1	0.0031	-0.00548	0.99452
75	leuct.016/case_20	208.77	2.11E-02	9.86E-02	1.88E-04	0.99285	0.00095	1	0.0031	-0.00715	0.99285
76	leuct.016/case_21	208.705	2.07E-02	9.91E-02	1.90E-04	0.99224	0.00096	1	0.0031	-0.00776	0.99224
77	leuct.016/case_22	208.725	2.01E-02	9.89E-02	1.82E-04	0.99347	0.0009	1	0.0031	-0.00653	0.99347
78	leuct.016/case_23	208.794	2.00E-02	9.84E-02	1.78E-04	0.99439	0.00098	1	0.0031	-0.00561	0.99439
79	leuct.016/case_24	208.725	2.05E-02	9.90E-02	1.87E-04	0.99301	0.00086	1	0.0031	-0.00699	0.99301
80	leuct.016/case_25	208.801	2.07E-02	9.84E-02	1.86E-04	0.9936	0.00092	1	0.0031	-0.0064	0.9936
81	leuct.016/case_26	208.776	2.01E-02	9.86E-02	1.78E-04	0.99506	0.00076	1	0.0031	-0.00494	0.99506
82	leuct.016/case_27	208.793	2.00E-02	9.84E-02	1.81E-04	0.99266	0.00085	1	0.0031	-0.00734	0.99266
83	leuct.016/case_28	208.98	2.11E-02	9.68E-02	1.89E-04	0.99311	0.00097	1	0.0031	-0.00689	0.99311
84	leuct.016/case_29	208.951	2.11E-02	9.71E-02	1.88E-04	0.99282	0.00085	1	0.0031	-0.00718	0.99282
85	leuct.016/case_30	208.947	2.03E-02	9.72E-02	1.80E-04	0.99202	0.00093	1	0.0031	-0.00798	0.99202
86	leuct.016/case_31	208.963	2.04E-02	9.69E-02	1.77E-04	0.99347	0.00079	1	0.0031	-0.00653	0.99347
87	leuct.016/case_32	209.002	2.03E-02	9.67E-02	1.78E-04	0.99398	0.00099	1	0.0031	-0.00602	0.99398
88	leust.003/case_1	218.044	3.40E-03	4.05E-02	1.61E-05	0.9987	0.00092	1.0007	0.0039	-0.002	0.998
89	leust.003/case_2	218.544	3.20E-03	3.87E-02	1.47E-05	0.99562	0.0009	1.0003	0.0042	-0.00468	0.99532
90	leust.003/case_3	218.635	3.10E-03	3.84E-02	1.47E-05	1.00286	0.0009	1.0005	0.0042	0.00236	1.00236
91	leust.003/case_4	218.679	3.03E-03	3.82E-02	1.46E-05	0.99412	0.001	1.0005	0.0042	-0.00638	0.99362

Results for Volume 4: LEU Systems, Rev. 0

N	Case	AFG	sigma	AELCF(ev)	sigma	k_calc LEU0	sigma	k_exp	sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU0*
92	leust.003/case_5	219.481	2.52E-03	3.55E-02	1.16E-05	0.99768	0.0008	1.0007	0.0048	-0.00302	0.99698
93	leust.003/case_6	219.571	2.48E-03	3.52E-02	1.14E-05	0.99871	0.00078	1.0009	0.0049	-0.00219	0.99781
94	leust.003/case_7	219.63	2.25E-03	3.50E-02	1.07E-05	0.99791	0.00085	1.0004	0.0049	-0.00249	0.99751
95	leust.003/case_8	219.959	2.04E-03	3.40E-02	9.68E-06	0.99971	0.0007	1.0003	0.0052	-0.00059	0.99941
96	leust.003/case_9	220.003	2.05E-03	3.39E-02	9.70E-06	0.99749	0.00062	1.0006	0.0052	-0.00311	0.99689
	Maximum	220.003	3.20E-02	3.02E-01	8.06E-04	1.00286	0.00123	1.0009	0.0052	0.00236	1.00236
	Average	206	2.21E-02	1.41E-01	3.07E-04	0.98901	0.00093	1.0000	0.0034	-0.01096	0.98904
	Minimum	195.664	2.04E-03	3.39E-02	9.68E-06	0.97513	0.00062	0.9997	0.002	-0.02467	0.97533

Results for Volume 4: LEU Systems, Rev. 1

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc LEU1	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU1*
1	lct008-08	2.46	6.06E-05	197.7	2.91E-02	2.53E-01	6.34E-04	0.99369	0.00082	1.0007	0.0012	-0.00701	0.99299
2	lct009-07	2.45	4.06E-05	207.4	2.13E-02	1.16E-01	2.10E-04	0.99599	0.00103	1	0.0021	-0.00401	0.99599
3	lct012-01	2.46	5.45E-05	202.1	2.71E-02	1.74E-01	4.14E-04	0.98027	0.00093	1	0.0034	-0.01973	0.98027
4	lct012-02	2.46	5.69E-05	201.6	2.71E-02	1.82E-01	4.29E-04	0.98192	0.00099	1	0.0034	-0.01808	0.98192
5	lct012-03	2.46	5.41E-05	201.5	2.62E-02	1.83E-01	4.09E-04	0.97939	0.00107	1	0.0034	-0.02061	0.97939
6	lct012-04	2.46	5.76E-05	201.0	2.77E-02	1.90E-01	4.59E-04	0.98207	0.00106	1	0.0034	-0.01793	0.98207
7	lct012-05	2.46	5.62E-05	201.1	2.64E-02	1.89E-01	4.42E-04	0.9823	0.0009	1	0.0034	-0.0177	0.9823
8	lct012-06	2.46	5.69E-05	201.1	2.73E-02	1.89E-01	4.53E-04	0.9833	0.00092	1	0.0034	-0.0167	0.9833
9	lct012-07	2.46	5.62E-05	201.1	2.67E-02	1.90E-01	4.44E-04	0.9829	0.00104	1	0.0034	-0.0171	0.9829
10	lct012-08	2.46	5.42E-05	201.4	2.70E-02	1.84E-01	4.29E-04	0.98005	0.00083	1	0.0049	-0.01995	0.98005
11	lct012-09	2.46	5.39E-05	202.3	2.48E-02	1.72E-01	3.74E-04	0.9803	0.00086	1	0.0034	-0.0197	0.9803
12	lct012-10	2.46	5.72E-05	201.7	2.57E-02	1.80E-01	4.10E-04	0.98142	0.00103	1	0.0034	-0.01858	0.98142

Results for Volume 4: LEU Systems, Rev. 1

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc LEU1	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff LEU1*
13	lmt001	2.46	6.42E-05	207.1	2.83E-02	1.20E-01	2.98E-04	0.99554	0.00085	0.999	0.0057	-0.00346	0.99654
14	lmt002-01	2.44	2.91E-05	217.2	1.36E-02	4.78E-02	6.81E-05	1.01571	0.00087	1	0.0141	0.01571	1.01571
15	lmt002-02	2.44	3.12E-05	216.2	1.54E-02	5.23E-02	8.25E-05	1.00911	0.00102	1	0.0141	0.00911	1.00911
16	lmt002-03	2.44	3.06E-05	216.7	1.55E-02	5.00E-02	8.24E-05	1.0151	0.00107	1	0.0141	0.0151	1.0151
17	lmt002-04	2.44	3.24E-05	213.8	1.69E-02	6.44E-02	1.04E-04	1.00788	0.00087	1	0.0141	0.00788	1.00788
18	lmt002-05	2.44	3.06E-05	216.8	1.45E-02	4.95E-02	7.66E-05	1.01812	0.0009	1	0.0141	0.01812	1.01812
19	lmt002-06	2.45	3.68E-05	210.0	2.03E-02	8.83E-02	1.61E-04	1.0078	0.00082	1	0.0146	0.0078	1.0078
20	lmt002-07	2.44	3.14E-05	215.7	1.49E-02	5.47E-02	7.88E-05	1.01248	0.00101	1	0.0141	0.01248	1.01248
21	lmt002-08	2.44	3.19E-05	214.7	1.65E-02	5.96E-02	9.74E-05	1.00511	0.00095	1	0.0141	0.00511	1.00511
22	lmt002-09	2.44	3.24E-05	215.8	1.50E-02	5.41E-02	8.29E-05	1.00846	0.00098	1	0.0141	0.00846	1.00846
23	lmt002-10	2.44	3.28E-05	215.2	1.57E-02	5.69E-02	9.08E-05	1.01023	0.00096	1	0.0141	0.01023	1.01023
24	lmt002-11	2.44	3.22E-05	214.2	1.62E-02	6.21E-02	9.90E-05	1.00766	0.00104	1	0.0141	0.00766	1.00766
25	lmt002-12	2.44	3.20E-05	216.4	1.53E-02	5.13E-02	7.93E-05	1.01428	0.00078	1	0.0141	0.01428	1.01428
26	lst004-01	2.44	4.90E-06	217.8	3.46E-03	4.16E-02	1.63E-05	1.00112	0.00084	0.9994	0.0008	0.00172	1.00172
27	lst004-29	2.44	4.63E-06	218.1	3.24E-03	4.05E-02	1.57E-05	1.002	0.00083	0.9999	0.0009	0.0021	1.0021
28	lst004-33	2.44	4.26E-06	218.4	3.20E-03	3.93E-02	1.55E-05	1.00011	0.00079	0.9999	0.0009	0.00021	1.00021
29	lst004-34	2.44	3.96E-06	218.6	3.01E-03	3.85E-02	1.41E-05	1.00226	0.00083	0.9999	0.001	0.00236	1.00236
30	lst004-46	2.44	3.77E-06	218.8	2.72E-03	3.80E-02	1.30E-05	1.00317	0.00095	0.9999	0.001	0.00327	1.00327
31	lst004-51	2.44	3.70E-06	218.9	2.87E-03	3.75E-02	1.35E-05	1.00034	0.00078	0.9994	0.0011	0.00094	1.00094
32	lst004-54	2.44	3.42E-06	219.1	2.66E-03	3.71E-02	1.27E-05	1.00166	0.00073	0.9996	0.0011	0.00206	1.00206
	Maximum	2.46	6.42007E-05	219.1	0.0291166	2.53E-01	6.34E-04	1.01812	0.00107	1.0007	0.0146	0.01812	1.01812
	Average	2.45	3.54716E-05	210.6	0.017369777	1.03E-01	2.07E-04	0.998179375	0.000917188	0.9999	0.0069	-0.00175	0.99825
	Minimum	2.44	3.4225E-06	197.7	0.00266273	3.71E-02	1.27E-05	0.97939	0.00073	0.999	0.0008	-0.02061	0.97939

Note: lmt002 series used infinite homogeneous, but latticecell or multiregion may be better.

Table 4.5 Results for Uranium-233 Systems (Volume 5) with CSAS25 from SCALE 4.4a and the 238-group Library on the J-5600 (CMODB) Workstation

Results for Volume 5: Uranium-233 Systems

								k_calc				Adjusted k-eff		
N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	U233	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	U233*	Notes
1	umf001-001	2.68	2.38E-04	22.5	1.32E-02	1.13E+06	1.41E+03	0.99178	0.00105	1	0.001	-0.00822	0.99178	
2	umf002-001	2.66	2.37E-04	22.8	1.32E-02	1.09E+06	1.38E+03	0.99447	0.00108	1	0.001	-0.00553	0.99447	48.479 %U235
3	umf002-002	2.65	2.31E-04	23.1	1.45E-02	1.07E+06	1.45E+03	0.99767	0.00108	1	0.0011	-0.00233	0.99767	48.4479 %U235
4	umf003-001	2.67	2.48E-04	23.0	1.37E-02	1.08E+06	1.41E+03	0.99685	0.00101	1	0.001	-0.00315	0.99685	
5	umf003-002	2.67	2.54E-04	23.1	1.41E-02	1.06E+06	1.46E+03	0.99901	0.0012	1	0.001	-0.00099	0.99901	
6	umf004-001	2.66	2.18E-04	24.1	1.34E-02	9.72E+05	1.24E+03	1.00028	0.001	1	0.0007	0.00028	1.00028	
7	umf004-002	2.65	2.11E-04	25.3	1.41E-02	8.69E+05	1.20E+03	1.00367	0.00102	1	0.0008	0.00367	1.00367	
8	umf005-001	2.66	2.42E-04	24.3	1.45E-02	9.45E+05	1.38E+03	0.99851	0.00109	1	0.003	-0.00149	0.99851	
9	umf005-002	2.65	2.22E-04	26.0	1.77E-02	7.64E+05	1.46E+03	1.00163	0.00093	1	0.003	0.00163	1.00163	
10	umf006-001	2.67	2.51E-04	23.6	1.54E-02	1.00E+06	1.43E+03	1.00043	0.00111	1	0.0014	0.00043	1.00043	
11	usi001_01	2.51	2.25E-05	148.8	4.34E-02	6.62E+00	1.95E-02	0.98903	0.00146	1	0.0083	-0.01097	0.98903	
12	usi001_02	2.51	2.41E-05	146.7	4.01E-02	7.71E+00	2.10E-02	0.98352	0.00158	1	0.0085	-0.01648	0.98352	
13	usi001_03	2.51	2.51E-05	145.7	4.06E-02	8.29E+00	2.29E-02	0.98386	0.00145	1	0.0066	-0.01614	0.98386	
14	usi001_04	2.51	2.36E-05	158.1	4.42E-02	3.54E+00	1.07E-02	0.99248	0.00124	1	0.0061	-0.00752	0.99248	
15	usi001_05	2.51	2.57E-05	144.8	4.26E-02	8.88E+00	2.58E-02	0.98611	0.00127	1	0.0082	-0.01389	0.98611	
16	usi001_06	2.51	2.56E-05	156.2	4.16E-02	4.09E+00	1.16E-02	0.98648	0.0014	1	0.0061	-0.01352	0.98648	
17	usi001_07	2.51	2.71E-05	144.3	4.15E-02	9.27E+00	2.60E-02	0.9846	0.00147	1	0.0059	-0.0154	0.9846	
18	usi001_08	2.51	2.63E-05	155.4	4.45E-02	4.36E+00	1.32E-02	0.97887	0.00157	1	0.0056	-0.02113	0.97887	
19	usi001_09	2.51	2.68E-05	148.3	4.27E-02	7.07E+00	2.07E-02	0.97742	0.00154	1	0.0068	-0.02258	0.97742	
20	usi001_10	2.51	2.80E-05	143.7	4.11E-02	9.72E+00	2.72E-02	0.97982	0.00147	1	0.0053	-0.02018	0.97982	
21	usi001_11	2.51	2.84E-05	147.7	4.14E-02	7.43E+00	2.09E-02	0.9809	0.00139	1	0.0057	-0.0191	0.9809	
22	usi001_12	2.50	2.05E-05	155.0	3.99E-02	4.30E+00	1.18E-02	0.98218	0.00131	1	0.0091	-0.01782	0.98218	
23	usi001_13	2.50	2.07E-05	153.2	3.84E-02	4.89E+00	1.27E-02	0.9817	0.00137	1	0.0071	-0.0183	0.9817	
24	usi001_14	2.50	2.01E-05	164.9	4.33E-02	2.17E+00	6.39E-03	0.99147	0.00118	1	0.0052	-0.00853	0.99147	
25	usi001_15	2.50	2.09E-05	152.3	3.80E-02	5.23E+00	1.35E-02	0.98228	0.00138	1	0.0075	-0.01772	0.98228	

Results for Volume 5: Uranium-233 Systems

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc U233	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff U233*	Notes
26	usi001_16	2.50	2.03E-05	168.5	4.33E-02	1.73E+00	5.16E-03	0.97377	0.00118	1	0.0028	-0.02623	0.97377	
27	usi001_17	2.50	2.03E-05	163.5	4.25E-02	2.42E+00	7.08E-03	0.98895	0.00128	1	0.0055	-0.01105	0.98895	
28	usi001_18	2.51	2.35E-05	151.4	3.87E-02	5.62E+00	1.51E-02	0.97868	0.0012	1	0.0057	-0.02132	0.97868	
29	usi001_19	2.51	2.24E-05	150.9	3.86E-02	5.86E+00	1.54E-02	0.97547	0.0015	1	0.0083	-0.02453	0.97547	
30	usi001_20	2.51	2.20E-05	161.3	4.18E-02	2.87E+00	8.13E-03	0.98098	0.00135	1	0.0056	-0.01902	0.98098	
31	usi001_21	2.51	2.42E-05	150.4	4.00E-02	6.09E+00	1.66E-02	0.97248	0.00143	1	0.005	-0.02752	0.97248	
32	usi001_22	2.51	2.60E-05	150.1	4.02E-02	6.24E+00	1.72E-02	0.97514	0.00162	1	0.0049	-0.02486	0.97514	
33	usi001_23	2.51	2.39E-05	154.9	3.95E-02	4.50E+00	1.21E-02	0.99051	0.00125	1	0.0047	-0.00949	0.99051	
34	usi001_24	2.50	1.50E-05	166.6	3.27E-02	1.90E+00	4.32E-03	0.99128	0.00132	1	0.0081	-0.00872	0.99128	
35	usi001_25	2.50	1.57E-05	164.8	3.51E-02	2.17E+00	5.16E-03	0.98705	0.00132	1	0.0081	-0.01295	0.98705	
36	usi001_26	2.50	1.65E-05	164.1	3.52E-02	2.29E+00	5.50E-03	0.98811	0.00127	1	0.0065	-0.01189	0.98811	
37	usi001_27	2.50	1.51E-05	173.4	3.75E-02	1.19E+00	3.09E-03	0.99176	0.00134	1	0.0051	-0.00824	0.99176	
38	usi001_28	2.50	1.81E-05	163.2	3.59E-02	2.45E+00	6.11E-03	0.98104	0.0014	1	0.0061	-0.01896	0.98104	
39	usi001_29	2.50	1.76E-05	162.8	3.40E-02	2.53E+00	5.94E-03	0.9769	0.00144	1	0.0098	-0.0231	0.9769	
40	usi001_30	2.50	1.67E-05	171.6	3.64E-02	1.38E+00	3.45E-03	0.97321	0.00123	1	0.0053	-0.02679	0.97321	
41	usi001_31	2.50	1.77E-05	162.6	3.59E-02	2.58E+00	6.38E-03	0.98828	0.00152	1	0.0071	-0.01172	0.98828	
42	usi001_32	2.50	2.01E-05	162.1	3.49E-02	2.68E+00	6.49E-03	0.9709	0.00132	1	0.0053	-0.0291	0.9709	
43	usi001_33	2.50	1.79E-05	166.5	3.90E-02	1.98E+00	5.30E-03	0.99067	0.00159	1	0.0046	-0.00933	0.99067	
44	ust001-001	2.50	7.24E-07	218.4	2.92E-03	3.86E-02	1.19E-05	0.99538	0.00084	1	0.0031	-0.00462	0.99538	
45	ust001-002	2.50	7.21E-07	218.2	2.93E-03	3.92E-02	1.23E-05	0.99711	0.00081	1.0005	0.0033	-0.00339	0.99661	
46	ust001-003	2.50	7.48E-07	218.1	2.98E-03	3.98E-02	1.20E-05	0.99749	0.00082	1.0006	0.0033	-0.00311	0.99689	
47	ust001-004	2.50	7.03E-07	217.9	3.20E-03	4.04E-02	1.34E-05	0.99583	0.00076	0.9998	0.0033	-0.00397	0.99603	
48	ust001-005	2.50	7.91E-07	217.7	3.38E-03	4.10E-02	1.44E-05	0.99597	0.00081	0.9999	0.0033	-0.00393	0.99607	
49	ust002-004	2.50	5.43E-06	200.4	2.00E-02	1.64E-01	2.51E-04	1.00472	0.00129	1.004	0.0087	0.00072	1.00072	
50	ust002-005	2.50	4.79E-06	203.6	1.68E-02	1.28E-01	1.67E-04	0.99023	0.00125	1.004	0.0087	-0.01377	0.98623	
51	ust002-008	2.50	3.95E-06	206.6	1.37E-02	1.00E-01	1.11E-04	1.008	0.0015	1.004	0.0087	0.004	1.004	
52	ust002-010	2.50	2.88E-06	209.2	1.18E-02	8.20E-02	8.00E-05	1.001	0.00107	1.004	0.0087	-0.003	0.997	
53	ust002-011	2.50	2.40E-06	210.9	9.92E-03	7.17E-02	5.85E-05	1.00677	0.00123	1.004	0.0087	0.00277	1.00277	

Results for Volume 5: Uranium-233 Systems

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc U233	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff U233*	Notes
54	ust002-012	2.50	2.31E-06	212.3	9.47E-03	6.41E-02	5.04E-05	0.99261	0.00136	1.004	0.0087	-0.01139	0.98861	
55	ust002-014	2.50	2.15E-06	212.9	8.50E-03	6.07E-02	4.44E-05	0.98183	0.00131	1.004	0.0087	-0.02217	0.97783	
56	ust002-015	2.50	1.68E-06	213.9	7.70E-03	5.60E-02	3.76E-05	0.99428	0.00116	1.004	0.0087	-0.00972	0.99028	
57	ust002-017	2.50	1.50E-06	215.1	6.07E-03	5.06E-02	2.79E-05	0.98476	0.00108	1.004	0.0087	-0.01924	0.98076	
58	ust002-018	2.50	1.29E-06	215.6	5.97E-03	4.89E-02	2.66E-05	0.99886	0.00117	1.004	0.0087	-0.00514	0.99486	
59	ust002-019	2.50	1.16E-06	216.4	4.99E-03	4.57E-02	2.06E-05	1.00613	0.00101	1.004	0.0087	0.00213	1.00213	
60	ust002-022	2.50	7.53E-06	194.5	2.54E-02	2.56E-01	4.81E-04	0.99228	0.00115	1.004	0.0087	-0.01172	0.98828	
61	ust002-024	2.50	1.12E-05	186.9	3.02E-02	4.53E-01	9.80E-04	0.9945	0.0014	1.004	0.0087	-0.0095	0.9905	
62	ust002-034	2.50	4.91E-06	203.1	1.78E-02	1.32E-01	1.81E-04	1.00061	0.00147	1.004	0.0087	-0.00339	0.99661	
63	ust002-035	2.50	3.44E-06	207.8	1.30E-02	9.19E-02	9.51E-05	1.00474	0.00121	1.004	0.0087	0.00074	1.00074	
64	ust002-036	2.50	2.04E-06	212.7	8.01E-03	6.17E-02	4.21E-05	1.00366	0.00108	1.004	0.0087	-0.00034	0.99966	
65	ust002-038	2.50	1.51E-06	214.6	6.64E-03	5.30E-02	3.10E-05	1.00374	0.00133	1.004	0.0087	-0.00026	0.99974	
66	ust003-040	2.50	9.09E-06	192.5	2.67E-02	2.99E-01	5.90E-04	0.9984	0.00138	0.9995	0.00871	-0.0011	0.9989	
67	ust004-003	2.50	6.09E-06	200.4	1.93E-02	1.64E-01	2.38E-04	0.99978	0.00144	1.0039	0.0088	-0.00412	0.99588	
68	ust004-006	2.50	4.80E-06	203.7	1.81E-02	1.27E-01	1.79E-04	1.00131	0.00128	1.0034	0.0086	-0.00209	0.99791	
69	ust004-020	2.50	7.76E-06	194.4	2.46E-02	2.59E-01	4.63E-04	0.99264	0.00131	1.0041	0.0089	-0.01146	0.98854	
70	ust004-025	2.50	1.13E-05	186.6	3.15E-02	4.64E-01	1.06E-03	0.98198	0.00126	1.0051	0.0089	-0.02312	0.97688	
71	ust004-027	2.50	1.09E-05	186.7	3.39E-02	4.60E-01	1.11E-03	1.00311	0.00146	1.002	0.0105	0.00111	1.00111	
72	ust004-028	2.50	9.42E-06	189.8	2.87E-02	3.65E-01	7.52E-04	0.99672	0.00131	1.002	0.0104	-0.00528	0.99472	
73	ust004-030	2.50	9.62E-06	189.8	2.83E-02	3.66E-01	7.33E-04	0.99039	0.00148	1.0037	0.009	-0.01331	0.98669	
74	ust004-033	2.50	4.94E-06	203.2	1.75E-02	1.32E-01	1.77E-04	1.00141	0.00141	1.002	0.0102	-0.00059	0.99941	
75	ust005-001	2.50	1.97E-06	213.0	7.98E-03	6.03E-02	4.25E-05	0.99603	0.00127	1	0.004	-0.00397	0.99603	
76	ust005-002	2.50	1.61E-06	214.5	6.95E-03	5.31E-02	3.33E-05	1.00136	0.00107	1	0.0049	0.00136	1.00136	
77	ust006-004	2.50	1.27E-05	178.7	2.63E-02	8.23E-01	1.56E-03	0.99524	0.00134	1	0.0035	-0.00476	0.99524	
78	ust006-006	2.50	1.21E-05	178.5	2.89E-02	8.37E-01	1.75E-03	0.98692	0.00134	1	0.0035	-0.01308	0.98692	
79	ust006-009	2.50	1.04E-05	188.7	2.92E-02	3.93E-01	8.23E-04	1.00025	0.00131	1	0.0028	0.00025	1.00025	
80	ust006-011	2.50	9.76E-06	188.8	2.82E-02	3.93E-01	7.89E-04	0.99748	0.00122	1	0.0028	-0.00252	0.99748	
81	ust006-015	2.50	7.57E-06	192.9	2.07E-02	2.87E-01	4.43E-04	0.98577	0.00125	1	0.0035	-0.01423	0.98577	

Results for Volume 5: Uranium-233 Systems

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc U233	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff U233*	Notes
82	ust006-018	2.50	7.69E-06	192.7	2.06E-02	2.90E-01	4.47E-04	0.98544	0.00133	1	0.0035	-0.01456	0.98544	
83	ust006-020	2.50	6.65E-06	199.4	2.02E-02	1.77E-01	2.69E-04	0.9907	0.00132	1	0.0028	-0.0093	0.9907	
84	ust006-022	2.50	6.75E-06	199.3	1.98E-02	1.77E-01	2.68E-04	0.98983	0.00131	1	0.0028	-0.01017	0.98983	
85	ust008-001	2.50	5.64E-07	219.1	2.34E-03	3.65E-02	9.58E-06	0.99679	0.00067	1.0006	0.0029	-0.00381	0.99619	
86	ust012_1	2.50	5.72E-06	200.2	1.90E-02	1.66E-01	2.37E-04	0.99328	0.00127	0.999	0.0028	-0.00572	0.99428	
87	ust012_2	2.50	5.63E-06	200.8	1.90E-02	1.59E-01	2.29E-04	0.99448	0.00134	0.9993	0.0025	-0.00482	0.99518	
88	ust012_3	2.50	5.24E-06	202.3	1.68E-02	1.42E-01	1.81E-04	1.00184	0.00156	0.9994	0.0023	0.00244	1.00244	
89	ust012_4	2.50	3.72E-06	206.2	1.39E-02	1.04E-01	1.15E-04	0.99628	0.00125	1	0.0015	-0.00372	0.99628	
90	ust012_5	2.50	3.29E-06	208.2	1.18E-02	8.87E-02	8.54E-05	0.99887	0.00121	1	0.0071	-0.00113	0.99887	
91	ust012_6	2.50	2.78E-06	209.8	1.05E-02	7.84E-02	6.82E-05	0.99877	0.00111	0.9987	0.0011	7E-05	1.00007	
92	ust012_7	2.50	1.59E-06	214.7	6.59E-03	5.27E-02	3.02E-05	0.99616	0.00134	1	0.0038	-0.00384	0.99616	
93	ust012_8	2.50	1.48E-06	214.8	5.98E-03	5.24E-02	2.70E-05	0.99506	0.00117	1	0.0048	-0.00494	0.99506	
94	ust014-001	2.50	1.16E-05	183.5	2.92E-02	5.82E-01	1.23E-03	0.97733	0.00157	0.9976	0.0112	-0.02027	0.97973	
95	ust014-002	2.50	1.12E-05	182.8	2.75E-02	6.15E-01	1.21E-03	0.99058	0.00135	0.9976	0.0112	-0.00702	0.99298	
96	ust014-003	2.50	8.96E-06	192.7	2.61E-02	2.97E-01	5.60E-04	1.00792	0.00127	1	0.0074	0.00792	1.00792	
97	ust014-004	2.50	8.68E-06	193.0	2.75E-02	2.90E-01	5.71E-04	1.00661	0.00121	1	0.0089	0.00661	1.00661	
98	ust014-005	2.50	8.97E-06	194.4	2.59E-02	2.63E-01	4.95E-04	1.00903	0.00132	1	0.0089	0.00903	1.00903	
99	ust014-006	2.50	8.86E-06	194.9	2.66E-02	2.54E-01	4.86E-04	1.0058	0.00121	1	0.0089	0.0058	1.0058	
100	ust014-007	2.50	8.56E-06	195.3	2.67E-02	2.46E-01	4.77E-04	1.00309	0.00121	1	0.0088	0.00309	1.00309	
101	ust014-008	2.50	8.31E-06	195.8	2.67E-02	2.37E-01	4.58E-04	1.00617	0.00119	1	0.0091	0.00617	1.00617	
102	ust014-009	2.50	9.00E-06	192.7	2.75E-02	2.96E-01	5.98E-04	1.00977	0.00121	1	0.0054	0.00977	**1.00977**	
103	ust014-010	2.50	9.53E-06	190.6	2.81E-02	3.48E-01	7.06E-04	0.99294	0.0013	0.9992	0.0108	-0.00626	0.99374	
104	ust014-011	2.50	1.04E-05	187.9	2.64E-02	4.24E-01	7.94E-04	0.9972	0.00155	0.9992	0.0126	-0.002	0.998	
105	ust014-012	2.50	9.31E-06	192.6	2.97E-02	3.00E-01	6.41E-04	1.00291	0.00128	0.9992	0.0097	0.00371	1.00371	
106	ust014-013	2.50	9.50E-06	193.1	3.14E-02	2.90E-01	6.55E-04	1.00181	0.00141	0.9992	0.0104	0.00261	1.00261	
107	ust014-014	2.50	8.97E-06	193.2	3.03E-02	2.87E-01	6.27E-04	0.996	0.00134	0.9966	0.0095	-0.0006	0.9994	
108	ust014-015	2.50	9.40E-06	192.1	3.04E-02	3.13E-01	6.78E-04	0.99299	0.00137	0.9966	0.0098	-0.00361	0.99639	
109	ust014-016	2.50	1.09E-05	185.0	2.80E-02	5.21E-01	1.04E-03	0.9767	0.00135	0.9965	0.0109	-0.0198	0.9802	

Results for Volume 5: Uranium-233 Systems

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc U233	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff U233*	Notes
110	ust015_01	2.50	1.23E-05	175.0	3.05E-02	1.05E+00	2.25E-03	0.98669	0.00149	1	0.0075	-0.01331	0.98669	
111	ust015_02	2.50	1.28E-05	173.4	2.96E-02	1.18E+00	2.42E-03	0.98295	0.00128	1	0.007	-0.01705	0.98295	
112	ust015_03	2.50	1.33E-05	172.8	3.13E-02	1.24E+00	2.70E-03	0.98663	0.00145	1	0.0068	-0.01337	0.98663	
113	ust015_04	2.50	1.17E-05	181.1	3.15E-02	6.86E-01	1.54E-03	0.9886	0.00144	1	0.0041	-0.0114	0.9886	
114	ust015_05	2.50	1.37E-05	172.0	3.21E-02	1.31E+00	2.93E-03	0.98395	0.00134	1	0.0055	-0.01605	0.98395	
115	ust015_06	2.50	1.43E-05	171.6	3.19E-02	1.36E+00	2.98E-03	0.97425	0.00149	1	0.0099	-0.02575	0.97425	
116	ust015_07	2.50	1.31E-05	180.0	3.12E-02	7.53E-01	1.69E-03	0.98348	0.00148	1	0.007	-0.01652	0.98348	
117	ust015_08	2.50	1.38E-05	171.3	3.21E-02	1.40E+00	3.15E-03	0.97011	0.00135	1	0.0067	-0.02989	0.97011	
118	ust015_09	2.50	1.53E-05	170.9	3.19E-02	1.43E+00	3.23E-03	0.96649	0.00154	1	0.005	-0.03351	**0.96649**	
119	ust015_10	2.50	1.50E-05	175.1	3.05E-02	1.07E+00	2.31E-03	0.98769	0.00129	1	0.0051	-0.01231	0.98769	
120	ust015_11	2.50	9.77E-06	181.4	2.84E-02	6.63E-01	1.34E-03	0.99014	0.00146	1	0.0075	-0.00986	0.99014	
121	ust015_12	2.50	1.02E-05	180.1	2.81E-02	7.31E-01	1.45E-03	0.99048	0.00127	1	0.0069	-0.00952	0.99048	
122	ust015_13	2.50	1.08E-05	179.4	2.93E-02	7.69E-01	1.60E-03	0.99047	0.00131	1	0.0069	-0.00953	0.99047	
123	ust015_14	2.50	1.02E-05	187.1	2.89E-02	4.41E-01	9.08E-04	0.99569	0.00136	1	0.0036	-0.00431	0.99569	
124	ust015_15	2.50	1.10E-05	178.9	2.84E-02	8.03E-01	1.62E-03	0.98781	0.00129	1	0.006	-0.01219	0.98781	
125	ust015_16	2.50	1.11E-05	178.5	2.92E-02	8.27E-01	1.70E-03	0.98444	0.00157	1	0.0043	-0.01556	0.98444	
126	ust015_17	2.50	1.07E-05	186.2	2.89E-02	4.80E-01	9.99E-04	0.99206	0.0015	1	0.0029	-0.00794	0.99206	
127	ust015_18	2.50	1.22E-05	178.1	2.83E-02	8.55E-01	1.72E-03	0.97233	0.00153	1	0.0056	-0.02767	0.97233	
128	ust015_19	2.50	1.29E-05	177.9	2.90E-02	8.65E-01	1.81E-03	0.97259	0.0016	1	0.0052	-0.02741	0.97259	
129	ust015_20	2.50	6.02E-06	193.3	2.24E-02	2.78E-01	4.52E-04	0.99107	0.00125	1	0.0079	-0.00893	0.99107	
130	ust015_21	2.50	6.52E-06	192.1	2.16E-02	3.03E-01	4.82E-04	0.9934	0.00126	1	0.007	-0.0066	0.9934	
131	ust015_22	2.50	6.63E-06	191.6	2.17E-02	3.16E-01	5.06E-04	0.99152	0.0014	1	0.0062	-0.00848	0.99152	
132	ust015_23	2.50	7.31E-06	191.1	2.14E-02	3.28E-01	5.14E-04	0.99204	0.00132	1	0.0055	-0.00796	0.99204	
133	ust015_24	2.50	7.48E-06	190.8	2.20E-02	3.35E-01	5.55E-04	0.98643	0.00136	1	0.0051	-0.01357	0.98643	
134	ust015_25	2.50	6.65E-06	196.9	2.03E-02	2.14E-01	3.15E-04	0.99277	0.00138	1	0.0023	-0.00723	0.99277	
135	ust015_26	2.50	3.56E-06	204.0	1.46E-02	1.22E-01	1.42E-04	0.98927	0.0015	1	0.0066	-0.01073	0.98927	
136	ust015_27	2.50	3.58E-06	203.6	1.42E-02	1.26E-01	1.39E-04	0.99331	0.00135	1	0.0063	-0.00669	0.99331	
137	ust015_28	2.50	3.56E-06	203.4	1.43E-02	1.28E-01	1.48E-04	0.99313	0.00138	1	0.0058	-0.00687	0.99313	

Results for Volume 5: Uranium-233 Systems

N	Case	nubar	Sigma	AFG	Sigma	EALCF (ev)	sigma	k_calc U233	sigma	Benchmark k-eff	Sigma	Bias = Calculated - Benchmark	Adjusted k-eff U233*	Notes
138	ust015_29	2.50	3.94E-06	203.2	1.44E-02	1.31E-01	1.47E-04	0.99028	0.00139	1	0.0051	-0.00972	0.99028	
139	ust015_30	2.50	3.74E-06	203.1	1.43E-02	1.31E-01	1.45E-04	0.99091	0.00126	1	0.0048	-0.00909	0.99091	
140	ust015_31	2.50	4.19E-06	203.0	1.48E-02	1.33E-01	1.53E-04	0.99285	0.00153	1	0.0055	-0.00715	0.99285	
	Maximum	2.68	2.54E-04	219.1	4.45E-02	1.13E+06	1.46E+03	1.00977	0.00162	1.0051	0.0126	0.00977	1.00977	
	Average	2.51	2.69E-05	174.4	2.47E-02	7.13E+04	9.87E+01	0.99141	0.00130	1.00052	0.0062	-0.0091	0.9909	
	Minimum	2.50	5.64E-07	22.5	2.34E-03	3.65E-02	9.58E-06	0.96649	0.00067	0.9965	0.0007	-0.03351	0.96649	

Table 4.6 Results for Mixed Plutonium - Uranium Systems (Volume 6) with CSAS25 from SCALE 4.4a and the 238-group Library on the J-5600 (CMODB) Workstation

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
1	CT005	ct005-01	2.843	4.28E-05	194.2	0.032	3.95E-01	1.08E-03	0.996	0.0009	1.0008	0.0022		-0.005	0.995
2		ct006-01	2.809	5.17E-05	194.9	0.033	3.76E-01	1.07E-03	0.991	0.001	1.0016	0.0051		-0.01	0.99
3	CT007	ct007-093array	2.8	4.37E-05	202.5	0.025	1.97E-01	4.43E-04	1.001	0.001	1.0023	0.0035		-0.001	0.999
4		ct007-105al	2.798	4.34E-05	206.5	0.024	1.40E-01	3.14E-04	0.996	0.0008	1.0024	0.0045		-0.007	0.993
5		ct007-105alcd	2.798	4.47E-05	206.3	0.024	1.42E-01	3.17E-04	0.994	0.001	1.0028	0.0044		-0.009	0.991
6		ct007-105array	2.798	3.97E-05	206.3	0.024	1.41E-01	3.05E-04	0.999	0.0011	1.0024	0.0039		-0.003	0.997
7		ct007-105b1	2.798	4.35E-05	206.3	0.023	1.41E-01	2.99E-04	0.993	0.001	1.0024	0.0044		-0.009	0.991
8		ct007-105b1cd	2.798	4.26E-05	206.3	0.022	1.42E-01	2.91E-04	0.993	0.0009	1.0022	0.0044		-0.01	0.99
9		ct007-105b2	2.798	4.17E-05	206.4	0.024	1.41E-01	3.20E-04	0.993	0.0008	1.0026	0.0044		-0.009	0.991

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
10		ct007-105b2cd	2.798	4.45E-05	206.3	0.024	1.42E-01	3.28E-04	0.991	0.001	1.0025	0.0044		-0.012	0.988
11		ct007-105b3	2.798	4.03E-05	206.4	0.023	1.41E-01	2.96E-04	0.993	0.0008	1.0027	0.0044		-0.009	0.991
12		ct007-105b3cd	2.798	4.16E-05	206.3	0.023	1.42E-01	3.10E-04	0.991	0.001	1.0025	0.0044		-0.011	0.989
13		ct007-105b4	2.798	4.36E-05	206.4	0.023	1.41E-01	3.03E-04	0.995	0.001	1.0025	0.0044		-0.008	0.992
14		ct007-105b4cd	2.798	4.10E-05	206.3	0.024	1.42E-01	3.08E-04	0.992	0.0009	1.0029	0.0044		-0.011	0.989
15		ct007-105cdair	2.798	4.47E-05	206.3	0.023	1.42E-01	3.00E-04	0.992	0.0011	1.0029	0.0044		-0.011	0.989
16		ct007-105cdh2o	2.798	4.22E-05	206.2	0.023	1.43E-01	3.02E-04	0.993	0.0008	1.0028	0.0044		-0.01	0.99
17		ct007-105h1	2.798	4.16E-05	206.4	0.024	1.41E-01	3.14E-04	0.994	0.0011	1.0026	0.0044		-0.009	0.991
18		ct007-105h1cd	2.798	4.15E-05	206.3	0.025	1.42E-01	3.20E-04	0.992	0.0009	1.0025	0.0044		-0.011	0.989
19		ct007-105h2	2.798	4.05E-05	206.3	0.024	1.41E-01	3.09E-04	0.994	0.001	1.0024	0.0044		-0.008	0.992
20		ct007-105h2cd	2.798	4.25E-05	206.3	0.023	1.42E-01	3.08E-04	0.992	0.0008	1.0023	0.0044		-0.01	0.99
21		ct007-105h3	2.798	3.89E-05	206.4	0.022	1.41E-01	2.86E-04	0.993	0.0009	1.002	0.0044		-0.009	0.991
22		ct007-105h3cd	2.798	4.25E-05	206.3	0.023	1.42E-01	3.00E-04	0.992	0.0009	1.002	0.0044		-0.01	0.99
23		ct007-105h4	2.798	4.44E-05	206.4	0.023	1.40E-01	3.07E-04	0.995	0.001	1.0021	0.0044		-0.007	0.993
24		ct007-105h4cd	2.798	4.13E-05	206.3	0.024	1.42E-01	3.08E-04	0.992	0.0008	1.0021	0.0044		-0.01	0.99
25		ct007-105h5	2.798	3.92E-05	206.4	0.024	1.41E-01	3.14E-04	0.995	0.0009	1.002	0.0044		-0.007	0.993
26		ct007-105h5cd	2.798	4.03E-05	206.3	0.022	1.42E-01	2.97E-04	0.991	0.0008	1.0025	0.0044		-0.011	0.989
27		ct007-1143arra	2.797	3.91E-05	208.3	0.021	1.19E-01	2.33E-04	1.001	0.0009	1.0036	0.0046		-0.002	0.998
28		ct007-132array	2.796	3.87E-05	210.6	0.019	9.66E-02	1.78E-04	1.003	0.0009	1.0037	0.0057		-0.001	0.999
29		ct007-1386arra	2.795	3.67E-05	211.2	0.02	9.17E-02	1.76E-04	1	0.0009	1.0044	0.0061		-0.004	0.996
30	CT008	ct008-001	2.799	5.26E-05	194.1	0.032	4.02E-01	1.10E-03	0.991	0.0009	0.9997	0.0032		-0.009	0.991
31		ct008-002	2.796	4.55E-05	202.4	0.024	1.99E-01	4.37E-04	0.997	0.0009	1.0008	0.003		-0.004	0.996
32		ct008-003	2.794	4.07E-05	206.2	0.023	1.42E-01	3.02E-04	0.998	0.0009	1.0023	0.0038		-0.004	0.996
33		ct008-004	2.793	4.31E-05	208.2	0.021	1.19E-01	2.42E-04	1.001	0.0009	1.0015	0.0047		-0.001	0.999
34		ct008-005	2.792	3.69E-05	210.6	0.019	9.70E-02	1.79E-04	1.002	0.0008	1.0022	0.0056		0	1
35		ct008-006	2.791	3.54E-05	211.2	0.019	9.19E-02	1.69E-04	1.002	0.0008	1.0028	0.0065		-0.001	0.999
36		ct008-al	2.794	4.24E-05	206.3	0.024	1.41E-01	3.13E-04	0.997	0.001	1.0023	0.0039		-0.005	0.995
37		ct008-alc	2.794	4.25E-05	206.2	0.022	1.42E-01	2.99E-04	0.995	0.0008	1.0023	0.0041		-0.007	0.993

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
38		ct008-b1	2.794	4.43E-05	206.3	0.023	1.42E-01	3.04E-04	0.994	0.0009	1.0023	0.0039		-0.008	0.992
39		ct008-b1c	2.794	4.30E-05	206.2	0.023	1.43E-01	3.04E-04	0.993	0.001	1.0023	0.0041		-0.009	0.991
40		ct008-b2	2.794	4.02E-05	206.2	0.022	1.42E-01	2.84E-04	0.995	0.0009	1.0023	0.0039		-0.008	0.992
41		ct008-b2c	2.794	4.40E-05	206.2	0.023	1.42E-01	3.06E-04	0.993	0.0009	1.0023	0.0041		-0.009	0.991
42		ct008-b3	2.794	4.37E-05	206.3	0.022	1.41E-01	2.93E-04	0.996	0.001	1.0023	0.0039		-0.007	0.993
43		ct008-b3c	2.794	4.23E-05	206.2	0.024	1.42E-01	3.07E-04	0.994	0.0009	1.0023	0.0041		-0.008	0.992
44		ct008-b4	2.794	4.26E-05	206.3	0.023	1.42E-01	3.08E-04	0.994	0.0009	1.0023	0.0039		-0.008	0.992
45		ct008-b4c	2.794	4.43E-05	206.2	0.023	1.43E-01	3.05E-04	0.993	0.0009	1.0023	0.0041		-0.009	0.991
46		ct008-cd	2.794	4.40E-05	206.2	0.024	1.43E-01	3.14E-04	0.993	0.0008	1.0023	0.004		-0.009	0.991
47		ct008-cdh2o	2.794	4.39E-05	206.2	0.024	1.42E-01	3.07E-04	0.993	0.001	1.0023	0.004		-0.009	0.991
48		ct008-h1	2.794	4.35E-05	206.3	0.024	1.42E-01	3.08E-04	0.993	0.0008	1.0023	0.0039		-0.01	0.99
49		ct008-h1c	2.794	4.14E-05	206.2	0.023	1.43E-01	3.05E-04	0.993	0.0008	1.0023	0.0041		-0.009	0.991
50		ct008-h2	2.794	4.48E-05	206.3	0.023	1.42E-01	3.04E-04	0.995	0.0009	1.0023	0.0039		-0.007	0.993
51		ct008-h2c	2.794	4.36E-05	206.2	0.025	1.43E-01	3.15E-04	0.995	0.0008	1.0023	0.0041		-0.007	0.993
52		ct008-h3	2.794	4.29E-05	206.3	0.024	1.42E-01	3.10E-04	0.996	0.0009	1.0023	0.0039		-0.006	0.994
53		ct008-h3c	2.794	4.52E-05	206.2	0.024	1.43E-01	3.15E-04	0.994	0.001	1.0023	0.0041		-0.008	0.992
54		ct008-h4	2.794	4.17E-05	206.3	0.024	1.41E-01	3.05E-04	0.996	0.0009	1.0023	0.0039		-0.007	0.993
55		ct008-h4c	2.794	4.41E-05	206.2	0.024	1.43E-01	3.14E-04	0.996	0.0009	1.0023	0.0041		-0.006	0.994
56		ct008-h5	2.794	4.38E-05	206.3	0.023	1.41E-01	2.97E-04	0.996	0.0009	1.0023	0.0039		-0.006	0.994
57		ct008-h5c	2.794	4.24E-05	206.2	0.023	1.43E-01	3.02E-04	0.994	0.0009	1.0023	0.0041		-0.008	0.992
58	CT009	ct009-01	2.858	4.69E-05	191	0.035	5.51E-01	1.68E-03	0.994	0.0009	1.0003	0.0054		-0.006	0.994
59	CT011	ct011-01	2.651	9.21E-05	187	0.05	5.61E-01	1.95E-03	1.003	0.001	1.002	0.0016		0.001	1.001
60	CT012	ct012-01	2.889	1.05E-05	206.6	0.012	1.46E-01	1.81E-04	0.976	0.001	1.0042	0.0058		-0.028	0.972
61		ct012-02	2.889	1.07E-05	206.5	0.013	1.46E-01	1.92E-04	0.978	0.0009	1.0042	0.0058		-0.026	0.974
62		ct012-03	2.889	1.04E-05	206.6	0.013	1.46E-01	1.88E-04	0.976	0.001	1.0042	0.0058		-0.029	0.971
63		ct012-04	2.889	1.01E-05	206.5	0.012	1.47E-01	1.82E-04	0.978	0.0011	1.0042	0.0058		-0.027	0.973
64		ct012-05	2.889	1.02E-05	206.5	0.012	1.47E-01	1.75E-04	0.979	0.001	1.0042	0.0058		-0.025	0.975
65		ct012-06	2.889	1.01E-05	206.5	0.012	1.47E-01	1.84E-04	0.98	0.0008	1.0042	0.0058		-0.024	0.976

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
66		ct012-07	2.886	4.29E-06	214.8	0.006	6.95E-02	5.02E-05	1.036	0.001	1.0023	0.0036		0.033	1.033
67		ct012-08	2.886	4.43E-06	214.8	0.006	6.93E-02	5.45E-05	1.03	0.001	1.0023	0.0036		0.027	1.027
68		ct012-09	2.886	4.22E-06	214.8	0.006	6.92E-02	5.24E-05	1.028	0.001	1.0023	0.0036		0.026	1.026
69		ct012-10	2.886	4.30E-06	214.8	0.006	6.91E-02	4.83E-05	1.025	0.001	1.0023	0.0036		0.023	1.023
70		ct012-11	2.886	4.51E-06	214.8	0.006	6.91E-02	5.38E-05	1.028	0.001	1.0023	0.0036		0.026	1.026
71		ct012-12	2.886	4.44E-06	214.8	0.006	6.91E-02	5.42E-05	1.032	0.001	1.0023	0.0036		0.03	1.03
72		ct012-13	2.886	4.63E-06	214.8	0.005	6.95E-02	4.81E-05	1.04	0.0009	1.0023	0.0036		0.038	1.038
73		ct012-14	2.888	7.52E-06	206.6	0.014	1.49E-01	2.04E-04	1.019	0.0011	1.0002	0.0027		0.019	1.019
74		ct012-15	2.888	7.66E-06	206.6	0.013	1.49E-01	1.96E-04	1.018	0.0011	1.0002	0.0027		0.018	1.018
75		ct012-16	2.888	8.33E-06	206.7	0.012	1.48E-01	1.84E-04	1.016	0.0013	1.0002	0.0027		0.016	1.016
76		ct012-17	2.888	7.82E-06	206.8	0.012	1.47E-01	1.90E-04	1.015	0.0011	1.0002	0.0027		0.015	1.015
77		ct012-18	2.888	7.62E-06	206.8	0.012	1.47E-01	1.80E-04	1.015	0.001	1.0002	0.0027		0.015	1.015
78		ct012-19	2.888	7.85E-06	206.9	0.013	1.46E-01	1.95E-04	1.012	0.0011	1.0002	0.0027		0.011	1.011
79		ct012-20	2.888	9.27E-06	203.2	0.014	2.04E-01	2.75E-04	1.019	0.0012	1.0004	0.0037		0.019	1.019
80		ct012-21	2.888	9.32E-06	203.2	0.014	2.05E-01	2.85E-04	1.016	0.0013	1.0004	0.0037		0.015	1.015
81		ct012-22	2.888	8.89E-06	203.2	0.014	2.05E-01	2.68E-04	1.016	0.0013	1.0004	0.0037		0.015	1.015
82		ct012-23	2.89	8.81E-06	204.7	0.014	1.75E-01	2.41E-04	1.007	0.0011	0.9997	0.0049		0.008	1.008
83		ct012-24	2.89	8.46E-06	204.8	0.014	1.74E-01	2.38E-04	1.008	0.0011	0.9997	0.0049		0.008	1.008
84		ct012-25	2.89	8.18E-06	204.8	0.014	1.72E-01	2.42E-04	1.006	0.0011	0.9997	0.0049		0.007	1.007
85		ct012-26	2.89	8.20E-06	205	0.014	1.70E-01	2.41E-04	1.005	0.0013	0.9997	0.0049		0.005	1.005
86		ct012-27	2.89	8.28E-06	205.1	0.014	1.68E-01	2.28E-04	1.003	0.0011	0.9997	0.0049		0.003	1.003
87		ct012-28	2.89	8.12E-06	205.2	0.013	1.67E-01	2.16E-04	1.006	0.0011	0.9997	0.0049		0.006	1.006
88		ct012-29	2.89	7.95E-06	205.2	0.014	1.67E-01	2.31E-04	1.006	0.0011	0.9997	0.0049		0.007	1.007
89		ct012-30	2.89	7.98E-06	205.1	0.014	1.69E-01	2.31E-04	1.005	0.0013	0.9997	0.0049		0.006	1.006
90		ct012-31	2.89	9.46E-06	200.4	0.015	2.57E-01	3.63E-04	1.002	0.0011	1.0007	0.0052		0.002	1.002
91		ct012-32	2.89	9.40E-06	200.4	0.014	2.57E-01	3.68E-04	1.001	0.0012	1.0007	0.0052		0.001	1.001
92		ct012-33	2.89	9.32E-06	200.4	0.015	2.57E-01	3.63E-04	0.996	0.0013	1.0007	0.0052		-0.004	0.996
93	MF001	mf001-001	2.954	3.53E-04	22.3	0.013	1.15E+06	1.41E+03	0.993	0.0013	1	0.0016		-0.007	0.993

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
94	MF002	mf002-001	2.725	3.21E-04	24.3	0.015	9.39E+05	1.32E+03	1.004	0.0012	1	0.0042		0.004	1.004
95		mf002-002	2.722	2.95E-04	24.3	0.015	9.34E+05	1.30E+03	1.006	0.0011	1	0.0044		0.006	1.006
96		mf002-003	2.712	2.90E-04	24.4	0.016	9.32E+05	1.34E+03	1.005	0.0012	1	0.0048		0.005	1.005
97	MF007	mf007-01	2.844	3.67E-04	52.1	0.079	6.45E+04	4.38E+02	1.004	0.001	1	0.0088	1	0.004	1.004
98		mf007-02	2.829	3.60E-04	47	0.071	9.94E+04	6.25E+02	1.01	0.001	1	0.0044	1	0.01	1.01
99		mf007-03	2.801	3.53E-04	32.5	0.034	3.65E+05	1.24E+03	1.006	0.0011	1	0.0054	1	0.006	1.006
100		mf007-04	2.783	3.58E-04	27.8	0.02	6.05E+05	1.40E+03	1.005	0.0012	1	0.0054	1	0.004	1.005
101		mf007-05	2.759	3.30E-04	25.4	0.015	8.37E+05	1.22E+03	1.001	0.0011	1	0.0063	1	0.001	1.001
102		mf007-06	2.744	3.33E-04	24.5	0.014	9.31E+05	1.26E+03	0.997	0.0011	1	0.0069	1	-0.003	0.997
103		mf007-07	2.96	3.61E-04	47.1	0.077	1.02E+05	6.83E+02	1.01	0.0011	1	0.006	1	0.01	1.01
104		mf007-08	2.937	3.49E-04	40.5	0.064	1.79E+05	1.02E+03	1.007	0.001	1	0.0055	1	0.007	1.007
105		mf007-09	2.919	3.36E-04	35.6	0.049	2.74E+05	1.24E+03	1.007	0.001	1	0.0052	1	0.007	1.007
106		mf007-10	2.872	3.37E-04	27.8	0.022	6.00E+05	1.46E+03	1.004	0.0012	1	0.0051	1	0.004	1.004
107		mf007-11	2.844	3.65E-04	25.8	0.016	7.81E+05	1.35E+03	1.001	0.0011	1	0.0049	1	0.001	1.001
108		mf007-12	2.81	3.66E-04	24.4	0.014	9.37E+05	1.29E+03	0.999	0.0011	1	0.0059	1	-0.001	0.999
109		mf007-13	2.793	3.56E-04	23.7	0.013	1.01E+06	1.20E+03	0.998	0.0012	1	0.0064	1	-0.002	0.998
110		mf007-14	3.017	3.13E-04	33.5	0.047	3.40E+05	1.49E+03	1.011	0.001	1	0.006	1	0.011	1.011
111		mf007-15	2.99	3.05E-04	30.3	0.035	4.59E+05	1.57E+03	1.009	0.001	1	0.0059	1	0.009	1.009
112		mf007-16	2.929	3.23E-04	25.9	0.017	7.57E+05	1.42E+03	1.007	0.0013	1	0.0053	1	0.007	1.007
113		mf007-17	2.893	3.49E-04	24.7	0.015	8.89E+05	1.31E+03	1.004	0.0011	1	0.0053	1	0.004	1.004
114		mf007-18	2.852	3.84E-04	23.7	0.014	9.99E+05	1.27E+03	1.003	0.0011	1	0.0057	1	0.003	1.003
115		mf007-19	2.976	3.23E-04	24.8	0.016	8.70E+05	1.49E+03	1.006	0.001	1	0.0062	1	0.006	1.006
116		mf007-20	2.937	3.69E-04	23.8	0.015	9.78E+05	1.39E+03	1.003	0.0014	1	0.0056	1	0.003	1.003
117		mf007-21	2.893	3.51E-04	23.1	0.014	1.06E+06	1.35E+03	1.002	0.0011	1	0.0058	1	0.002	1.002
118		mf007-22	3.018	3.30E-04	23.9	0.015	9.68E+05	1.40E+03	1.004	0.0012	1	0.0055	1	0.004	1.004
119		mf007-23	2.975	3.25E-04	23.2	0.014	1.04E+06	1.37E+03	1.001	0.0011	1	0.0053	1	0.001	1.001
120	MF009	mf009	3.059	2.96E-04	21.9	0.013	1.19E+06	1.40E+03	0.996	0.0013	1	0.001		-0.004	0.996
121	MF010	mf010	2.844	3.56E-04	23.1	0.013	1.07E+06	1.34E+03	0.996	0.0013	1	0.0009		-0.004	0.996

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
122	MF011	mf011-021b	2.91	1.32E-04	34.8	0.022	2.78E+05	6.99E+02	1.001	0.0008	0.9897	0.0023		0.011	1.011
123		mf011-021c	2.784	1.38E-04	33.8	0.02	3.18E+05	7.19E+02	1.005	0.001	0.9998	0.0023		0.005	1.005
124		mf011-021d	2.694	1.42E-04	37.4	0.025	2.08E+05	5.70E+02	1.009	0.0008	1.0018	0.0024		0.007	1.007
125		mf011-021e	2.604	1.29E-04	35.8	0.021	2.56E+05	6.16E+02	1.008	0.0008	1.0012	0.0024		0.007	1.007
126	MT001	mt001-106	2.885	4.73E-05	193.5	0.045	3.92E-01	1.33E-03	0.996	0.001	1	0.0044		-0.004	0.996
127		mt001-107	2.885	4.07E-05	188.6	0.039	5.79E-01	1.71E-03	1.002	0.0011	1	0.0044		0.002	1.002
128		mt001-109	2.885	4.24E-05	190.8	0.038	4.85E-01	1.39E-03	1.004	0.001	1	0.0044		0.004	1.004
129		mt001-110	2.885	4.39E-05	192.5	0.042	4.23E-01	1.32E-03	0.998	0.001	1	0.0044		-0.002	0.998
130		mt001-111	2.885	4.18E-05	185.6	0.037	7.29E-01	2.00E-03	1.005	0.001	1	0.0044		0.005	1.005
131		mt001-112	2.886	3.91E-05	183.9	0.036	8.48E-01	2.22E-03	1.002	0.0011	1	0.0032		0.002	1.002
132		mt001-113	2.886	3.90E-05	182.4	0.036	9.64E-01	2.56E-03	1.006	0.0008	1	0.0032		0.006	1.006
133		mt001-114	2.886	3.52E-05	181.1	0.037	1.08E+00	2.77E-03	1.002	0.001	1	0.0032		0.002	1.002
134		mt001-115	2.886	3.57E-05	180.2	0.034	1.18E+00	2.82E-03	1.004	0.0008	1	0.0066		0.004	1.004
135		mt001-116	2.886	3.41E-05	179.7	0.036	1.22E+00	2.98E-03	1.005	0.0009	1	0.0066		0.005	1.005
136		mt001-117	2.884	5.27E-06	209.5	0.01	1.14E-01	1.20E-04	1.021	0.0011	1	0.0025		0.021	1.021
137	ST001	st001-a100	2.884	5.07E-06	210.1	0.009	1.08E-01	1.14E-04	1.009	0.0012	1	0.0052		0.009	1.009
138		st001-a108	2.884	3.90E-06	212.8	0.008	8.34E-02	7.51E-05	1	0.001	1	0.0016		0	1
139		st001-a87	2.884	7.44E-06	205.6	0.012	1.60E-01	1.98E-04	0.997	0.0011	1	0.0016		-0.003	0.997
140		st001-a87s	2.884	7.50E-06	205.5	0.013	1.61E-01	2.08E-04	0.998	0.0011	1	0.0016		-0.002	0.998
141		st001-a91	2.884	6.75E-06	205.9	0.013	1.57E-01	2.01E-04	0.992	0.0011	1	0.0016		-0.008	0.992
142		st001-a92	2.884	7.04E-06	205	0.012	1.70E-01	2.08E-04	0.997	0.001	1	0.0016		-0.003	0.997
143		st001-a93	2.884	7.36E-06	204.5	0.013	1.75E-01	2.31E-04	1	0.0011	1	0.0016		0	1
144		st001-a94	2.884	7.88E-06	205	0.013	1.69E-01	2.18E-04	1	0.0012	1	0.0016		0	1
145		st001-a95	2.892	1.01E-05	198.5	0.017	2.83E-01	4.26E-04	1.001	0.0012	1	0.0016		0.001	1.001
146		st001-a96	2.891	7.57E-06	206.5	0.013	1.49E-01	1.87E-04	1.002	0.0011	1	0.0016		0.002	1.002
147		st001-a97	2.891	5.41E-06	211.8	0.01	9.17E-02	9.56E-05	1.003	0.001	1	0.0016		0.003	1.003
148		st001-a98	2.884	5.58E-06	209.4	0.011	1.15E-01	1.30E-04	1.002	0.001	1	0.0016		0.002	1.002
149		st001-a99	2.884	5.45E-06	209.8	0.01	1.11E-01	1.25E-04	1.007	0.001	1	0.0052		0.007	1.007

Results for Volume 6: Mixed Plutonium - Uranium Systems

N	Category	Case	nubar	sigma	AFG	sigma	EALCF(ev)	Sigma	k_calc Pu-U	Sigma	Benchmark k-eff	Sigma	Note	Bias = Calculated - Benchmark	Adjusted k-eff Pu-U*
150	ST002	st002-b11058	2.89	1.67E-06	219.5	0.002	4.19E-02	1.49E-05	1.007	0.0009	1	0.0024		0.007	1.007
151		st002-b11059	2.89	1.60E-06	219.6	0.002	4.18E-02	1.46E-05	1.009	0.0007	1	0.0024		0.009	1.009
152		st002-b63061	2.887	1.55E-06	219.3	0.002	4.28E-02	1.66E-05	1.008	0.0007	1	0.0024		0.008	1.008
153	ST004	st004-d15677	2.889	1.12E-05	196.1	0.018	3.52E-01	5.41E-04	0.999	0.0011	1	0.0026		-0.001	0.999
154		st004-d16678	2.889	1.05E-05	199.3	0.017	2.66E-01	4.12E-04	0.997	0.0013	1	0.0026		-0.003	0.997
155		st004-d19669	2.889	7.38E-06	205.7	0.012	1.60E-01	1.97E-04	0.998	0.0011	1	0.0029		-0.002	0.998
156		st004-d20670	2.889	8.03E-06	203.7	0.013	1.92E-01	2.46E-04	0.997	0.0014	1	0.0029		-0.003	0.997
157		st004-d25665	2.889	3.59E-06	214.6	0.006	7.08E-02	5.43E-05	1	0.0011	1	0.0033		0	1
158		st004-d26666	2.889	3.37E-06	215.2	0.005	6.68E-02	4.82E-05	1.003	0.0011	1	0.0033		0.003	1.003
159		st004-f17583	2.889	9.67E-06	198	0.017	3.01E-01	4.45E-04	0.979	0.0011	1	0.0077		-0.021	0.979
160		st004-f18568	2.889	7.18E-06	204.9	0.012	1.72E-01	2.13E-04	0.984	0.001	1	0.0078		-0.016	0.984
161		st004-f27567	2.889	3.61E-06	214.9	0.006	6.90E-02	5.08E-05	0.982	0.0011	1	0.0068		-0.018	0.982
162	ST005	st005-c13175	2.889	1.11E-05	196	0.018	3.54E-01	5.45E-04	0.989	0.001	1	0.0037		-0.011	0.989
163		st005-c22b74	2.889	7.94E-06	203.6	0.012	1.94E-01	2.43E-04	0.99	0.0013	1	0.0037		-0.01	0.99
164		st005-c23b63	2.889	3.57E-06	214.6	0.006	7.05E-02	5.05E-05	0.997	0.001	1	0.0037		-0.003	0.997
165		st005-d14176	2.889	1.04E-05	200	0.016	2.53E-01	3.75E-04	0.997	0.0013	1	0.0037		-0.003	0.997
166		st005-d21171	2.889	7.46E-06	206.1	0.012	1.55E-01	1.85E-04	1.001	0.0012	1	0.0037		0.001	1.001
167		st005-d21172	2.889	7.32E-06	206.3	0.012	1.52E-01	1.85E-04	1	0.001	1	0.0037		0	1
168		st005-d24164	2.889	3.58E-06	215.3	0.006	6.62E-02	4.91E-05	1.003	0.001	1	0.0037		0.003	1.003
		Maximum	3.059	3.84E-04	219.6	0.079	1.19E+06	1.57E+03	1.04	0.0014	1.0044	0.009		0.038	1.038
		Average	2.85	8.23E-05	170.4	0.02	1.33E+05	2.33E+02	1.001	0.001	1.001	0.004		0	1
		Minimum	2.604	1.55E-06	21.92	0.002	4.18E-02	1.46E-05	0.976	0.0007	0.9897	0.001		-0.029	0.971

Note 1: Experimental Uncertainty for MMF007 is maximum sum from Table 5 in OECD report.

5 Results Analysis

5.1 Introduction

The data in Tables 4.1 through 4.6 provides information for performing analysis of the calculation results, experiment (benchmark) data, and the bias results.

The OECD reports provide an estimate of the actual k_{eff} for each experiment model. While benchmarks for most experiments were estimated to be exactly critical, or k_exp = 1.0, a number of the estimates were above or below exactly critical. It was considered desirable to account for this difference. The following adjustment, to determine an adjusted calculation result, k', was used to calculate adjusted k-effective:

$$k' = 1 + bias = 1 + (k_cal - k_exp)$$

where k_cal = code calculated k_{eff} result for the modeled experiment, and
k_exp = OECD estimate of actual k_{eff} for the modeled experiment

The assumption inherent in making this adjustment is that the experiments were close to critical, and if a small adjustment could be made so that the experiment would be exactly critical, the bias of the calculation would not change.

When calculation methods are employed, the subcritical limit is a quantitative value used for implementation of NCSD policy, which is established in accordance with DOE Orders, Standards, or by NRC regulations for those activities under NRC jurisdiction. Evaluation criteria are usually the calculated reactivity, k_{eff}, for the model of the problem being evaluated, uncertainty in the calculated value of reactivity, bias introduced by the code used to calculate reactivity, and bias introduced by the model. Code bias is determined by a validation performed in accordance with ANSI/ANS 8.1. The statistical results determine code bias based on comparison of code calculations with experimental results. Model bias is due to uncertainties in the modeled parameters describing the problem, approximations made for the model to conform to the input requirements of the code, and any significant simplifications of the problem introduced into the model by the analyst. The acceptance criterion requires that the evaluation criteria be bounded by the subcritical limit. In the case of code calculations, the subcritical limit is often a criterion based on calculated k_{eff} and estimated bias and uncertainties.

It is recognized that it may also be possible to determine subcritical limits based on adjustment of correlating parameters other than k_{eff}, as allowed by ANSI/ANS-8.1. These parameters could include physical parameters such as mass or radius, for example, or other calculated parameters besides k_{eff}, if they can be shown to provide subcritical margin. This report does not address other potential correlating parameters, but an analyst could determine them as part of an evaluation and use them to determine subcritical limits in conjunction with the code bias results in this report.

5.2 Discussion of Results

Figure 1 shows a plot of all adjusted k-effective results versus EALCF, or the Energy corresponding to the Average Lethargy of neutrons Causing Fission. EALCF or average energy group has traditionally been used as a trending variable. The amount of data in the middle energy range is somewhat sparse relative to the low and high ends; however, with a few exceptions there are at least some results in almost every energy range. As expected, most k-eff results are centered about 1.0, and are generally within a range of about 1.0 +0.04/-0.03, with the exception of a few results that are outside the range. These high and low data will be discussed in more detail below.

There appears to be a small systematic more negative bias for U-233 results, relative to other fissile categories, in the thermal to intermediate energy range, and some indication of a slight trend in the bias with energy. Otherwise, none of the fissile species appears to consistently have a different bias than other categories, and no other major trends in results are seen.

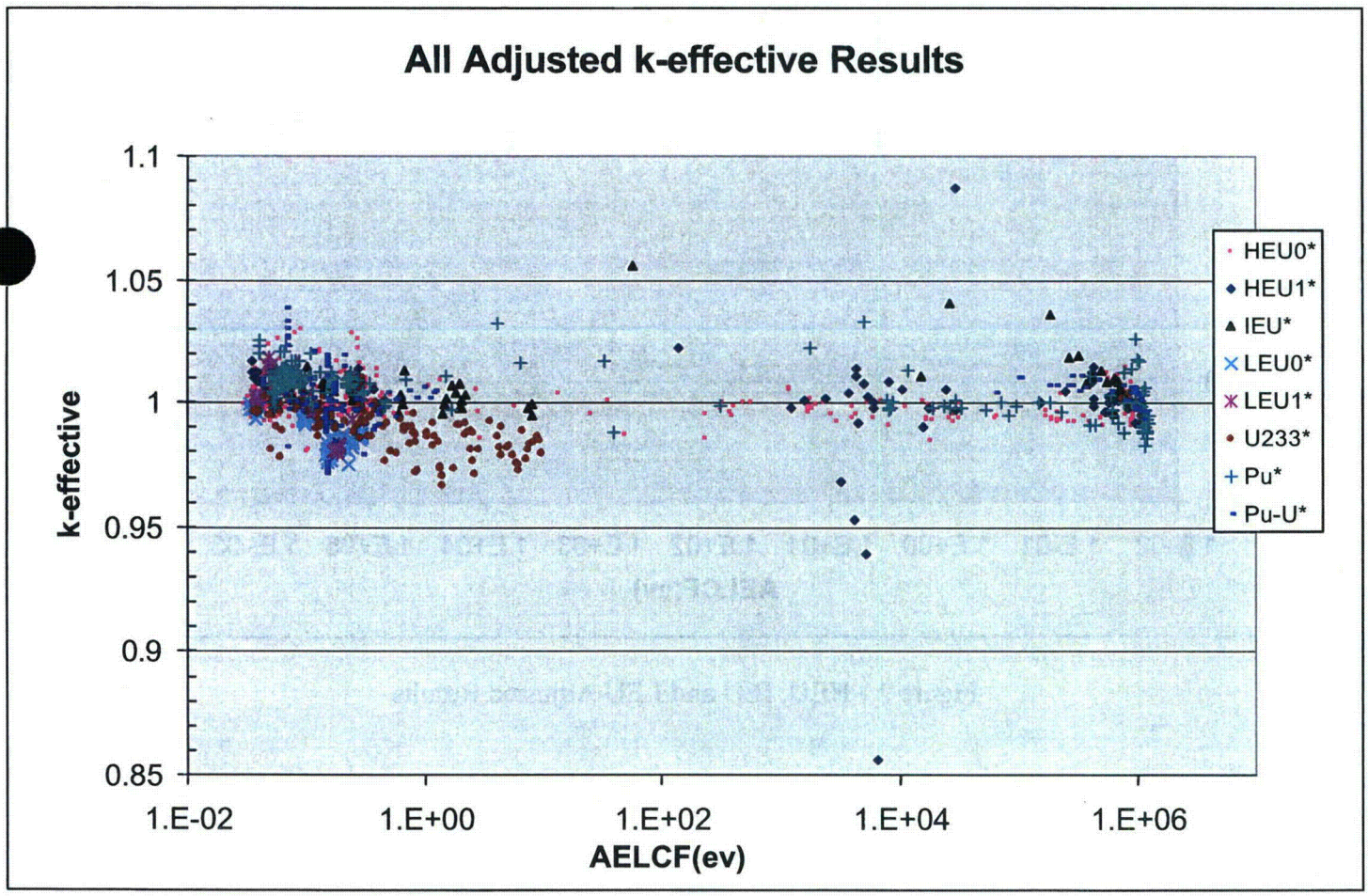


Figure 1 - All Adjusted Results

Figure 2 shows a plot of the HEU, IEU and LEU adjusted k-eff results versus EALCF. While Figure 2 appears to show a possible cluster of LEU results with more negative bias, this is not really the case, as seen in Figure 3, which shows a plot of the LEU results alone.

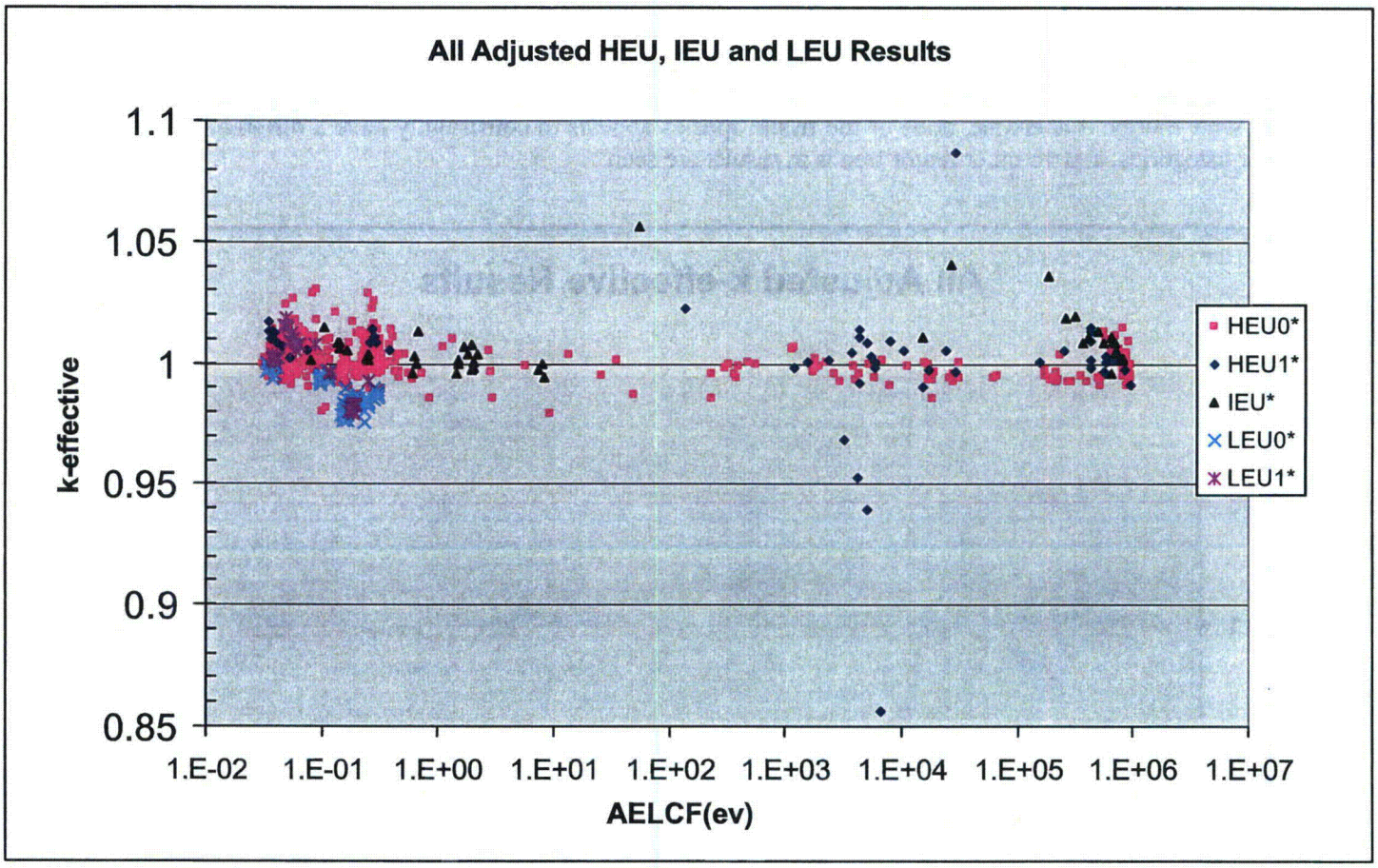


Figure 2 - HEU, IEU and LEU Adjusted Results

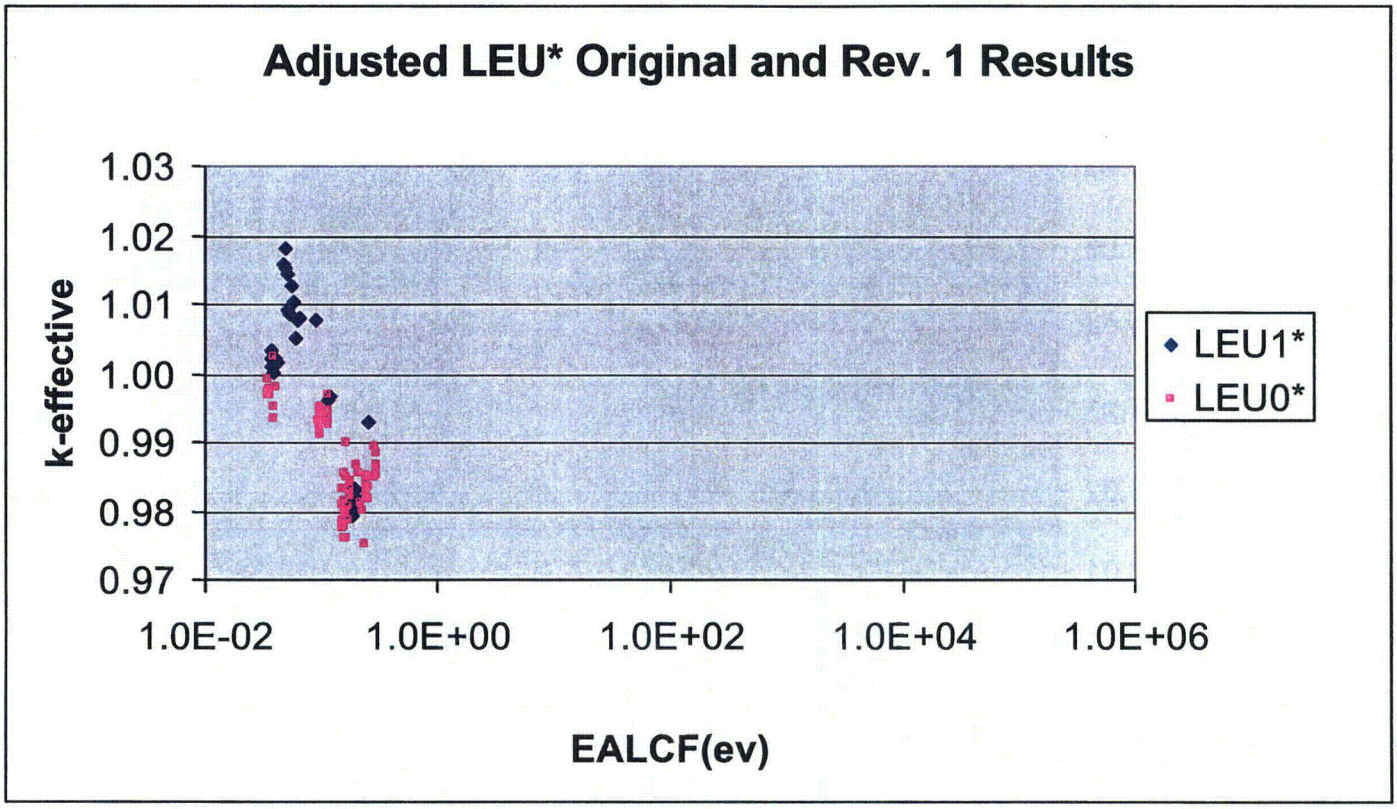


Figure 3 - LEU Adjusted k-eff Results

Figure 4 shows a plot of the IEU adjusted k-eff results versus EALCF. Also highlighted is the fact that several of the "outlying" results are from k-infinite models, which are somewhat different than the usual benchmark experiment, and exaggerate the effects of cross section imperfections. In this category, all the "outlying" results have positive bias.

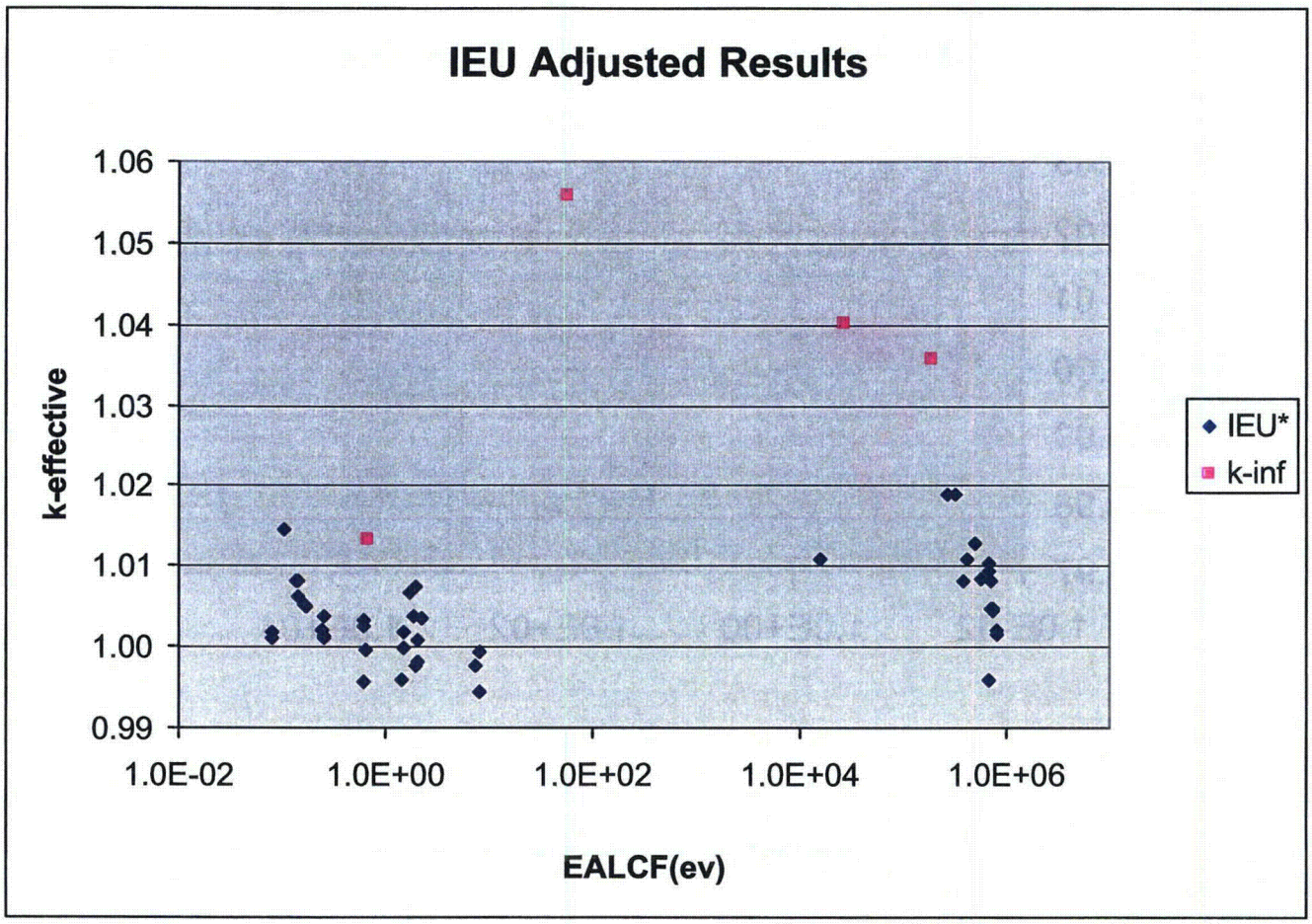


Figure 4 - IEU Adjusted k-eff Results

Figure 5 shows a plot of the HEU adjusted k-eff results versus EALCF. Also highlighted is the fact that four of the "outlying" results, including those having the most negative bias, are from k-infinite models, which are somewhat different than the usual benchmark experiment, and exaggerate the effects of cross section imperfections. It is also clear that one of the HEU results has a very high, positive bias.

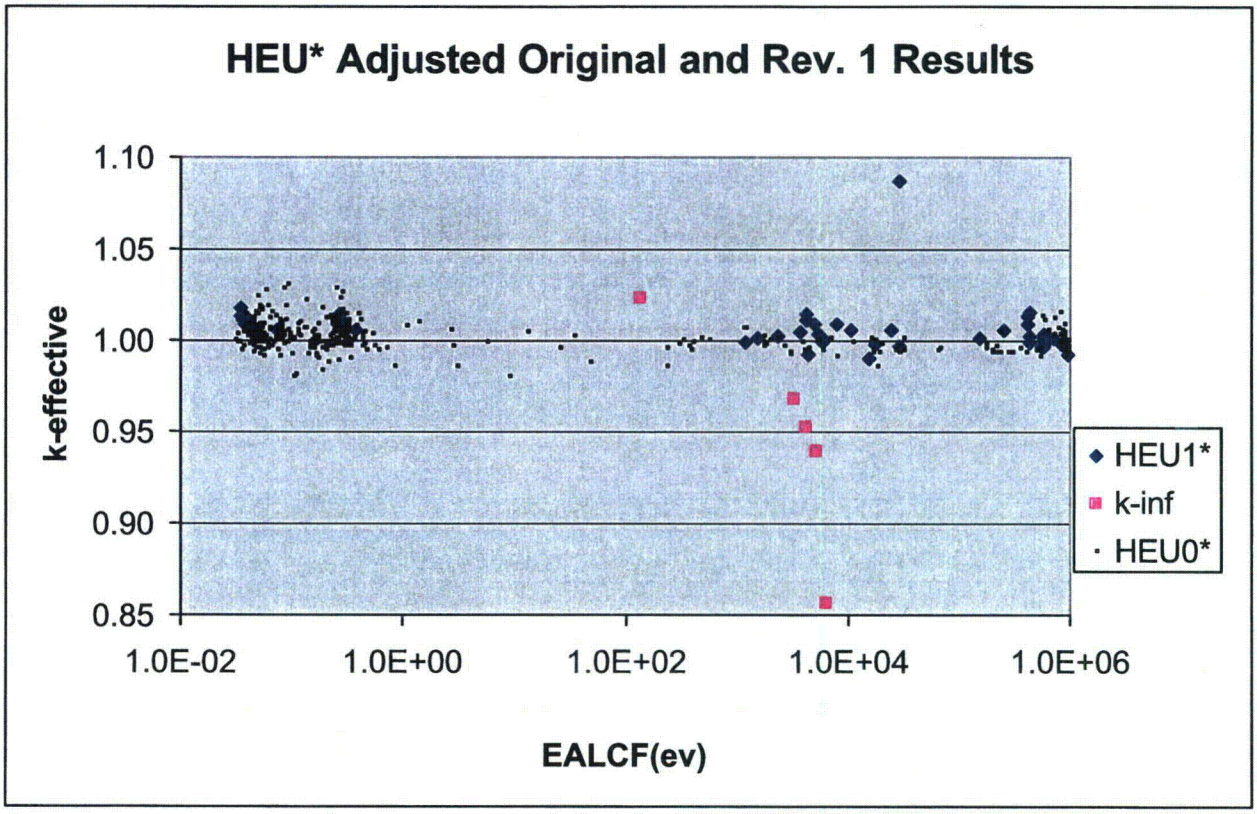


Figure 5 - HEU Adjusted k-eff Results

Figure 6 shows a plot of the adjusted U-233 k-eff results versus EALCF. While this plot appears to confirm the slightly more negative bias at low energies, the existence of a trend with energy appears questionable.

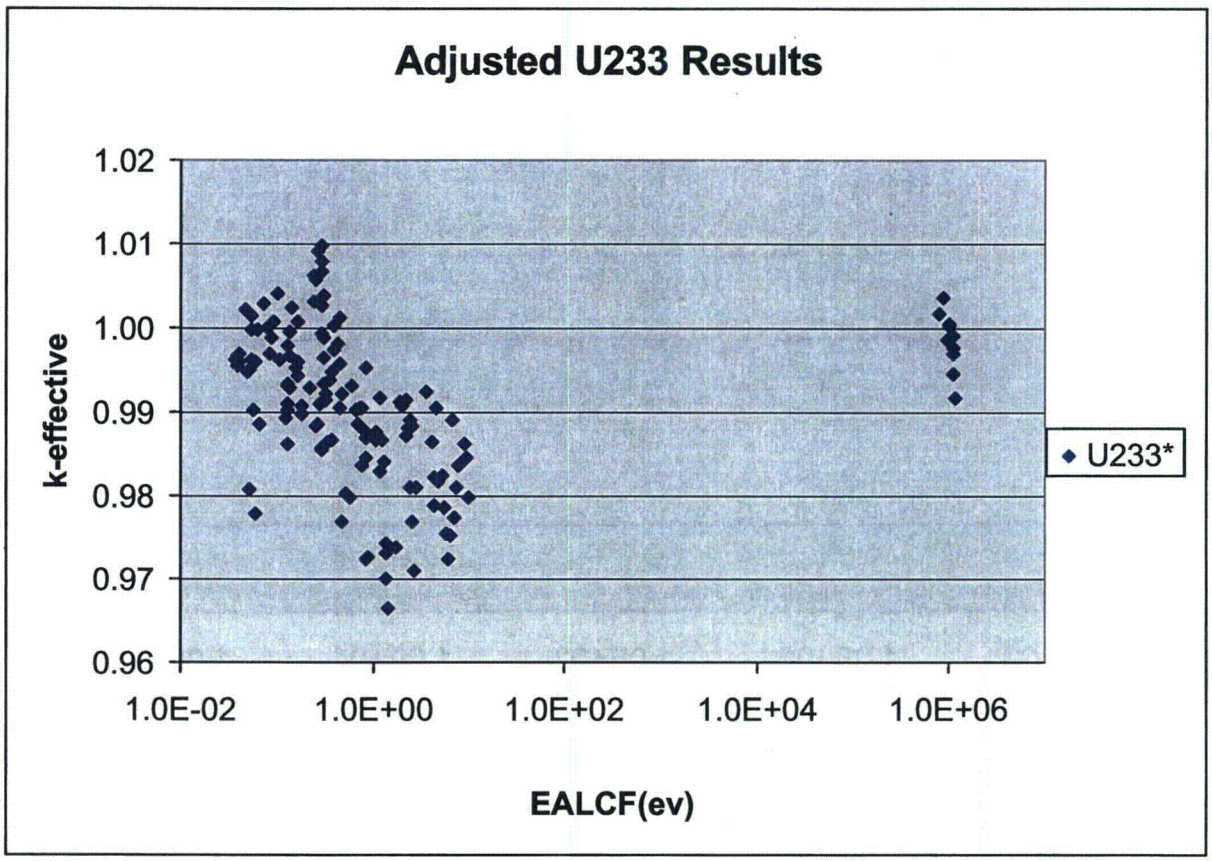


Figure 6 - U-233 Adjusted k-eff Results

Figure 7 shows a plot of the adjusted Pu and Mixed Pu-U results versus EALCF. These results are from Y/DD-996[iv]. The results appear to be consistent with the uranium results (as also seen in Figure 1), although the range of results is generally somewhat larger (excluding "outlying" results in uranium results).

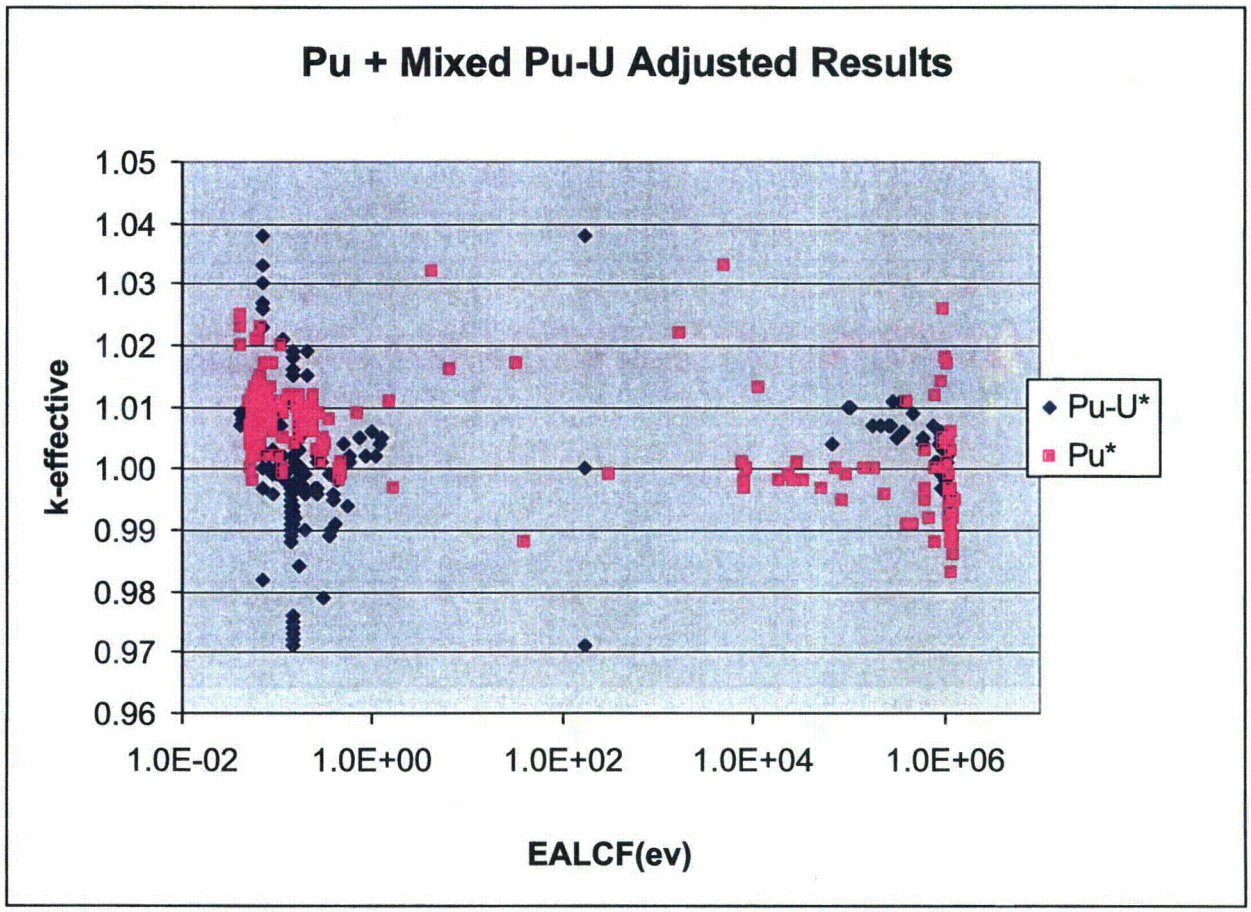


Figure 7 - Pu and Mixed Pu-U Adjusted k-eff Results

Figure 8 shows a plot of adjusted k-eff results versus nubar, or the average number of neutrons produced per fission. Nubar values were not collected for HEU and LEU results from revision 0 of this report; therefore, only a subset of the results is shown. The value of nubar depends on the fissile species and the neutron spectrum, and therefore is thought to possibly incorporate a couple important characteristics of critical systems, and has potential value as an Area of Applicability indicator. For the data plotted, there is no apparent trend across a fairly wide range of nubar values.

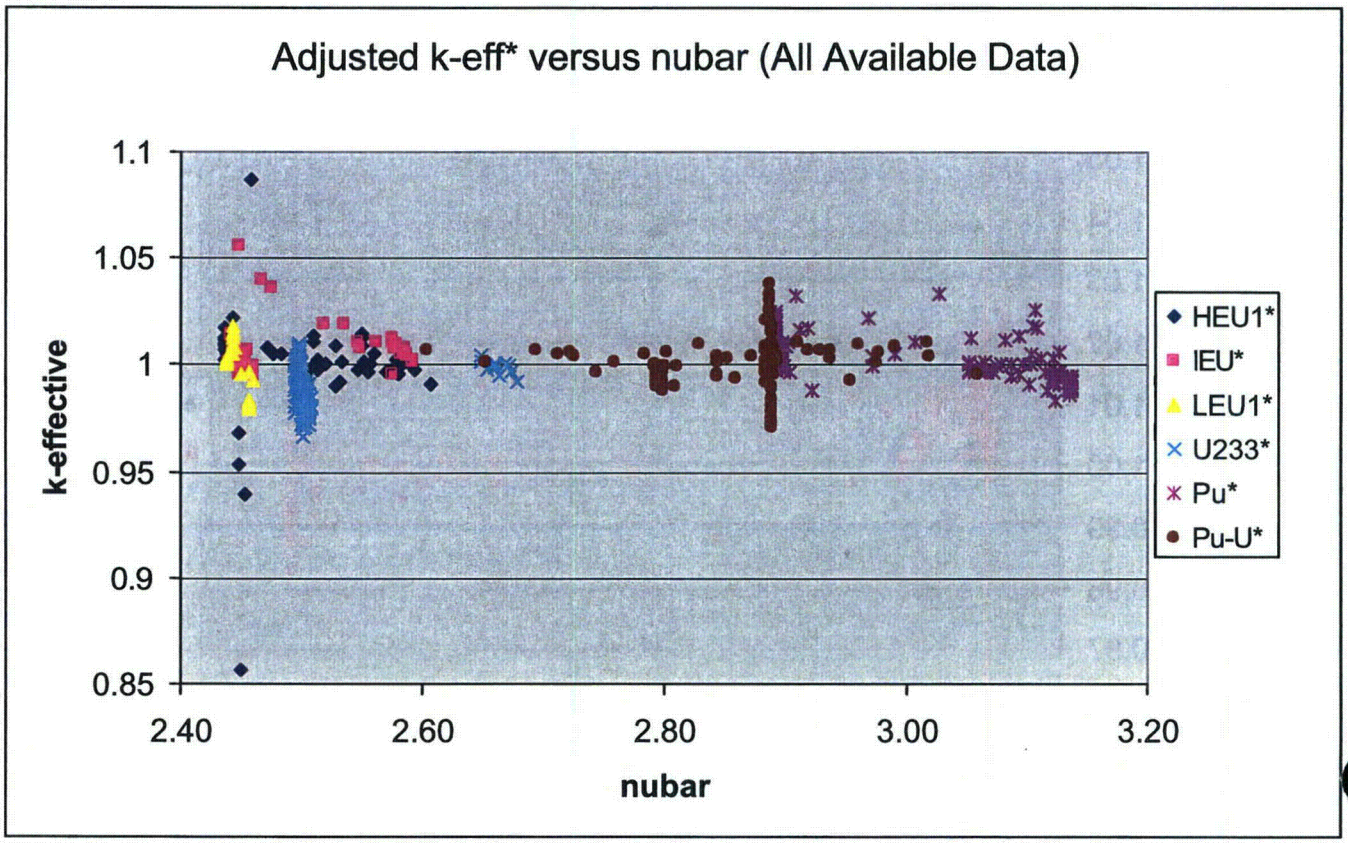


Figure 8 - Adjusted k-eff Results versus Nubar (for all available data)

Figure 9 shows a plot of "raw" calculated k-eff results versus "expected" benchmark k-eff. This illustrates the range of expected results, the range of calculated results, and the agreement between them. Ideally, the results should fall on a line from the lower left to the upper right. As shown, most data is clustered close to about (1.0,1.0), but several data points are significantly different, and experiments with expected results far from 1.0 also usually had larger bias results.

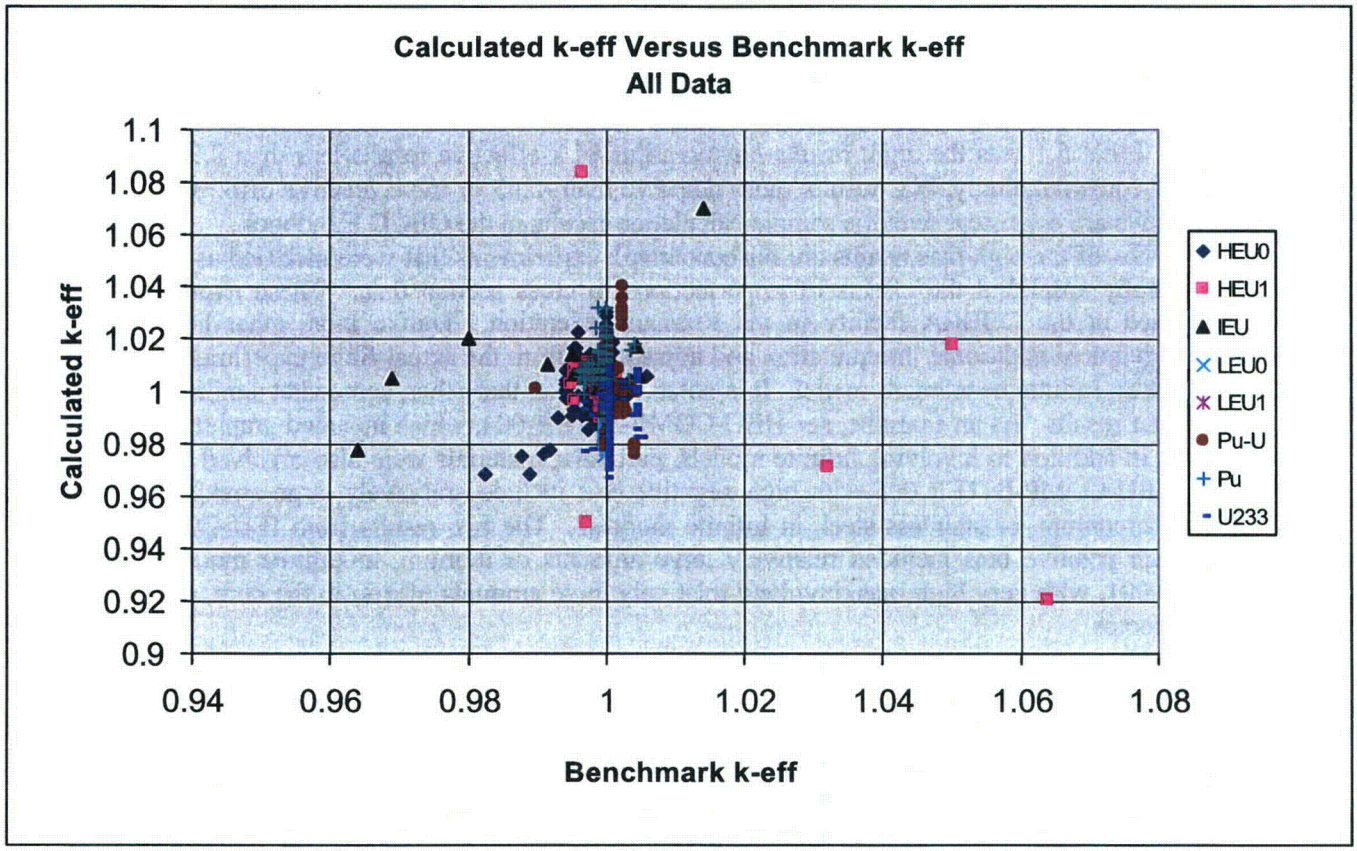


Figure 9 - Calculated k-eff Versus Benchmark k-eff

5.3 Discussion of High Positive and Negative Bias Results

Table 5.1 lists the eight results having adjusted k-effective results less than 0.97 or greater than 1.04, or correspondingly, bias results more negative than -0.03 or more positive than +0.04. These high bias results are consistent with the sample calculation results in the OECD Handbook.

Six of the high bias results are for benchmark experiments that were modeled as infinite in extent, and thereby amplified the effects of imperfections in cross section data. These experiments were all performed at the COBRA facility in the Russian Federation. Unlike most other benchmarks, these models required additional interpretation and adjustment from the actual finite experimental configuration to create an infinite benchmark model. It is noted, however, that other, somewhat similar, infinite models had better results. As an example, see HEU-COMP-INTER-004, which included graphite and boron.

In addition to involving infinite models, particular materials were also involved. The four results from HEU-COMP-INTER-005 with high negative bias included relatively large amounts of chromium, nickel, zirconium, or stainless steel, in infinite models. The two results from IEU-COMP-INTER-001 with high positive bias included relatively large amounts of thorium, in infinite models. HEU-MET-INTER-001, with very high bias, involved relatively large amounts of iron in the core, and stainless steel as a reflector.

No particular problem or unusual circumstance was found with U233-SOL-THERM-005 case 9. As discussed previously, the U-233 results appear to have a slightly more negative bias, in general, as a category, for low energies.

Because of the unusual aspects of the benchmark models, as discussed above, when establishing subcritical limits for general applications, consideration should be given to eliminating, or giving separate treatment to, the high positive and negative bias models HCI005-07,09,15,16; ICI001-002, 003, and HMI001. UST015_09 should be included, but it may be advisable to establish separate, slightly lower subcritical limits for U-233 applications.

Table 5.1 High Positive and Negative Bias Results

Case	nubar	AFG	EALCF(ev)	k_calc	k_exp	Bias = Calculated - Benchmark	k-eff*	Comment
hci005-15	2.45	60.7	6.50E+03	0.92044	1.064	-0.14356	0.85644	k-inf, Cr
hci005-07	2.45	63.8	5.09E+03	0.9712	1.032	-0.0608	0.9392	k-inf, Ni
hci005-16	2.45	64.1	4.18E+03	0.95005	0.997	-0.04695	0.95305	k-inf, Zr
ust015_09	2.50	170.9	1.43E+00	0.96649	1	-0.03351	0.96649	
hci005-09	2.45	66.5	3.21E+03	1.01827	1.05	-0.03173	0.96827	k-inf, St. Steel
ici001-002	2.47	52.075	2.66E+04	1.02029	0.980	0.0403	1.04029	k-inf
ici001-003	2.45	124.130	5.59E+01	1.06991	1.014	0.0559	1.05591	k-inf
hmi001	2.46	51.6	2.93E+04	1.08365	0.9966	0.08705	1.08705	Iron xs problem

5.4 Summary of Results

Tables 4.1-4.6 provide a summary of the calculation results for the benchmark critical experiments. The "raw" k-eff results (k_calc) do not account for the known differences between the estimated benchmark actual k_{eff} (k_exp) and the ideal critical k_{eff} (1.0). The benchmark experiments are near-critical experiments with expected neutron multiplication factors very close to unity. Some experiment benchmarks were enough different from unity to justify accounting for the difference. An "adjusted" k-eff is defined as 1+bias, where bias=k_calc-k_exp, and there results are also shown in Tables 4.1-4.6, and in Figures 1-8.

The only significant, noticeable difference in apparent bias of the results based on enrichment and physical form appears to be for U-233 thermal systems, which had a slightly more negative bias. In the previous revision, it appeared that the high-enriched experiments calculated slightly higher than the low enriched experiments, based on average results. Now, with more low enriched experiments included, the differences appear less pronounced. The difference in range of results has also become smaller. All results are for the 238-group library.

Since simulated infinite models have been included, the range of benchmark k-eff values has increased. Values range from 0.964 to 1.064. "Raw" calculated results ranged from 0.920 to 1.084. Other than a few cases, as shown in Figure 9, most benchmark and calculated results are very close to 1.0.

5.4.1 Area of Applicability

Whether a particular plant application is similar to a sufficient number of experiments contained in the validation set is an important issue. This is a prerequisite before a subcritical limit may be determined from the validation results. Based on the demonstrated performance of the code for a large number of experiments, we have reasonable assurance that it performs well over a wide range of conditions. However, this does not ensure that the code performs as well over all conditions. It does not guarantee that there is not a scenario where the code would calculate unusually low (or high) due to some kind of anomaly or limitation in the code or cross section data. There are some types of experiments that are one or two of a kind. It is possible that there could be one or more of these types of experiments that would exhibit a larger bias than seen in this report, if more experiments of that type were included. The

only way to assess whether the validation set contains a sufficient number of experiments that are similar to a plant application is to carefully compare the details of the experiment description with the details of the plant application. The experiment summary information included in this report, Appendix A, may not provide enough information. The analyst must become familiar with the experiment descriptions provided in the OECD handbook. The DICE database may be very helpful in this regard. The minimum number of similar experiments needed cannot be determined in advance, but the analyst must consider this issue carefully as one of the factors when deciding how much margin to include in determining a subcritical limit. If there are only a few experiments similar to the application, it may be wise to take the time to select additional applicable experiments for addition to the validation set, or to perform a separate evaluation.

Appropriateness of the subcritical limit does not depend solely on the validity of the statistical analysis. Rather, the appropriateness of a subcritical limit depends on two quite different factors: (1) the range of conditions under which a generalization for its use is established, and (2) whether or not the modeled scenario is within the range of these conditions. The criticality safety analyst exercising sound engineering judgment using strong technical arguments must develop these determinations. Extrapolation beyond the range of applicability should not be done.

5.4.2 Grandfather or Retrofit Concerns

The validation documents used for establishing subcritical limits for criticality calculations shall be reviewed and approved by NCSD. There is no urgency to retrofit older evaluations since the common practice provided conservatism. Therefore, the incorporation of the results in this report into the evaluations of existing operations will be accomplished as the Criticality Safety Approvals become obsolete and are replaced due to equipment changes, rule changes, age, etc.

6 Conclusions

This work has demonstrated the validation, or calibration, of the CSAS25 sequence of SCALE4.4a against 1217 benchmark experiments. It provides assurance that the code predicts critical or near critical systems reasonably well, however, in general, based on bias results there is wide variation in performance depending on the type of system. Using a rating scale similar to Reference iii, the performance ranges from "very good" or less than about +/- 0.01 to "very poor" or about +0.087/-0.14 depending on the category of experiments. In general, the previously observed problems resulted in very high bias, which would be conservative for plant applications. This report includes several benchmark cases that significantly under-predict the expected results. There is no guarantee against the possibility of an unusual scenario that could produce non-conservative results, and analysts must be always vigilant for this possibility.

The determination of appropriate correlating parameter and values for limits and additional margin, applicable to a particular analysis, must be determined as part of process analysis. This document does not specify final upper subcritical limits as has been done in the past. It is anticipated that a follow-on report will be written to recommend subcritical limits. Analysts using these results are responsible for

exercising sound engineering judgment using strong technical arguments to develop a margin in k_{eff} or other correlating parameter that is sufficiently large to ensure that conditions (calculated by this method to be subcritical by this margin) will actually be subcritical.

Documentation of determination and justification of the appropriate subcritical limit and margin in the analyst's evaluation, in conjunction with this report, will constitute the complete Validation Report in accordance with ANSI/ANS-8.1-1998, Section 4.3.6(4).

7 Recommendations for Future Work

A report determining subcritical limits applicable to calculated k_{eff}, should be completed soon after this report.

As stated in Section 3, numerous additional OECD experiment descriptions are already available for experiments that would be applicable to Y-12 work. In this regard, future efforts should be dedicated to the following: (1) developing more input decks in-house for experiments selected based on applicability to Y-12, and (2) including additional models as they become available in future revisions of the OECD report. In addition, changes in experiment categorization and interpretation/clarification sometimes are reported in the annual revisions of the OECD handbook. These changes should be reviewed to determine whether they impact the conclusions in this report. This work will require a dedicated effort.

Additional work may be needed to better categorize trends and/or biases by including additional parameters in the statistical evaluation.

Additional work is needed on Area of Applicability (AoA) determination methods. Determining whether a particular application is within the AoA of a validation is currently almost exclusively based on subjective judgment. To be done correctly, it requires the analyst to have close familiarity with the details of the experiments in the validation. Efforts to develop input models for more experiments, particularly if done by several staff members, would have the additional benefit of increasing staff's familiarity with experiment descriptions, which would also help improve these AoA determinations. Continuing such model input preparation work as part of the qualification program is suggested. In addition, methods have been proposed for more rigorous, and quantitative, AoA determinations. A dedicated effort is needed to evaluate these methods to determine if they are effective and practical to implement.

Areas of relatively very poor performance are seen, possibly due to cross section data issues. Efforts to produce improved cross section libraries for SCALE should be supported.

Appendix A - Comparison of Available Experiments with Calculated Experiments

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
Volume I	514	0	270	0	270	0	Plutonium Systems
Volume II	921	407	0	53	460	531	Highly Enriched Uranium Systems
Volume III	61	0	0	51	51	43	Intermediate and Mixed Enrichment Uranium Systems
Volume IV	927	96	0	32	128	0	Low Enriched Uranium Systems
Volume V	166	0	0	140	140	0	Uranium-233 Systems
Volume VI	250	0	168	0	168	176	Mixed Plutonium-Uranium Systems
Volume VII	20	0	0	0	0	0	Special Isotope Systems
Totals:	**2859**	**503**	**438**	**276**	**1217**	**750**	
Volume I, Plutonium Systems							
Pu METAL SYSTEMS							
FAST ENERGY Pu METAL SYSTEMS							
PU-MET-FAST-001	1		1		1		Bare Sphere of Plutonium-239 Metal (^{239}Pu Jezebel)
PU-MET-FAST-002	1		1		1		Bare Sphere of Plutonium-240 Metal (^{240}Pu Jezebel)
PU-MET-FAST-003	5		5		5		Unmoderated Plutonium Metal Button Array
PU-MET-FAST-004	9		9		9		Unmoderated Plutonium Metal Cylinder Array - Phase II
PU-MET-FAST-005	1		1		1		Plutonium Sphere Reflected by Tungsten
PU-MET-FAST-006	1		1		1		Plutonium Sphere Reflected by Normal Uranium Using Flattop

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
PU-MET-FAST-007	0	n/a	n/a			n/a	Four Plutonium Spheres with Various Reflector Materials
PU-MET-FAST-008	1		1		1		Thorium Reflected Plutonium Sphere
PU-MET-FAST-009	1		1		1		Plutonium Sphere Reflected by Aluminum
PU-MET-FAST-010	1		1		1		Delta-Phase Plutonium Sphere Reflected by Normal Uranium
PU-MET-FAST-011	1		1		1		Water Reflected Alpha-Phase Pu Sphere
PU-MET-FAST-012	1		1		1		Uranium-Reflected Array of Plutonium Fuel Rods
PU-MET-FAST-013	1		1		1		Copper-Reflected Array of Plutonium Fuel Rods
PU-MET-FAST-014	1		1		1		Nickel-Reflected Array of Plutonium Fuel Rods
PU-MET-FAST-015	1		1		1		Iron-Reflected Array of Plutonium Fuel Rods
PU-MET-FAST-016	6		6		6		Flooded 3x3x3 Arrays of 3-kg Plutonium Metal Cylinders - Phase I
PU-MET-FAST-017	5		5		5		Moderated Plutonium Metal Cylinders Array - Phase II
PU-MET-FAST-018	1		1		1		Delta-Phase Plutonium Sphere Reflected by Beryllium
PU-MET-FAST-019	1						Sphere of Plutonium Reflected by Beryllium
PU-MET-FAST-020	1						Sphere of Plutonium Reflected by Depleted Uranium
PU-MET-FAST-021	2						Beryllium- and Beryllium Oxide-Reflected Cylinders of Plutonium
PU-MET-FAST-022	1		1		1		Bare Spherical Assembly of ^{239}Pu(delta, 98%)
PU-MET-FAST-023	1		1		1		Graphite-Reflected Spherical Assembly of ^{239}Pu(delta, 98%)
PU-MET-FAST-024	1		1		1		Polyethylene-Reflected Spherical Assembly of ^{239}Pu(delta, 98%)
PU-MET-FAST-025	1		1		1		Spherical Assembly of ^{239}Pu(delta, 98%) with 1.55-cm Steel Reflector
PU-MET-FAST-026	1		1		1		Spherical Assembly of ^{239}Pu(delta, 98%) with 11.9-cm Steel Reflector
PU-MET-FAST-027	1		1		1		Polyethylene-Reflected Spherical Assembly of ^{239}Pu(delta, 89%)
PU-MET-FAST-028	1		1		1		Steel-Reflected Spherical Assembly of ^{239}Pu(delta, 89%)
PU-MET-FAST-029	1		1		1		Bare Spherical Assembly of ^{239}Pu(alpha, 88%)
PU-MET-FAST-030	1		1		1		Graphite-Reflected Spherical Assembly of ^{239}Pu(alpha, 88%)
PU-MET-FAST-031	1		1		1		Polyethylene-Reflected Spherical Assembly of ^{239}Pu(alpha, 88%)
PU-MET-FAST-032	1		1		1		Steel-Reflected Spherical Assembly of ^{239}Pu(alpha, 88%)
PU-MET-FAST-033	1		1		1		Cylindrical Assembly of Plutonium Metal Reflected by graphite
PU-MET-FAST-034	0	n/a	n/a			n/a	Asymmetric Spherical Plutonium Reflected by Steel and Oil

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
PU-MET-FAST-035	1		1		1		Spherical Assembly of ^{239}Pu(delta,98%) with 3.15-cm Lead reflector
PU-MET-FAST-036	1		1		1		sph assembly of ^{239}Pu(delta,98%) with compound refl of 0.05-cm Cd and 2.3-cm poly
PU-MET-FAST-037	16		7		7		flooded 2x2xN arrays of 3-kg Plutonium metal cylinders - Phase 2
PU-MET-FAST-039	1		1		1		spherical assembly of ^{239}Pu(delta,98%) with a 4.25-cm Duralumin reflector
PU-MET-FAST-040	1		1		1		spherical assembly of ^{239}Pu(delta,98%) with a 1.6-cm Copper reflector
PU-MET-FAST-041	1		1		1		sperical assembly of ^{239}Pu(alpha,88%) with a 20.98-cm Depleted-Uranium reflector
PU-MET-FAST-045	7						cyl assembly of Pu/Ta/Al metal discs with Fe/Ni/Poly/H_2O reflector (LAMPRE)
INTERMEDIATE ENERGY Pu METAL SYSTEMS							
PU-MET-INTER-001	0	n/a	n/a			n/a	refer to PU-MET-MIXED-001
PU-MET-INTER-002	1						cyl ZPR assembly with a Pu/C/SST core and a SST/FE reflector (ZPR-6/10)
THERMAL ENERGY Pu METAL SYSTEMS							
PU-MET-THERM-001	0	n/a	n/a			n/a	refer to PU-MET-MIXED-001
MIXED ENERGY Pu METAL SYSTEMS							
PU-MET-MIXED-001	6						heterogeneous compositions of Plutonium, Silicon Dioxide, and polyethylene
Pu COMPOUND SYSTEMS							
FAST ENERGY Pu COMPOUND SYSTEMS							
PU-COMP-FAST-001	0						refer to PU-COMP-MIXED-001
PU-COMP-FAST-002	0						refer to PU-COMP-MIXED-002
INTERMEDIATE ENERGY Pu COMPOUND SYSTEMS							

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
PU-COMP-INTER-001	1		1		1		k-infinity experiments in intermediate neutron spectra for ^{239}Pu
THERMAL ENERGY Pu COMPOUND SYSTEMS							
PU-COMP-THERM-001	0						refer to PU-COMP-MIXED-001
PU-COMP-THERM-002	0						refer to PU-COMP-MIXED-002
MIXED ENERGY Pu COMPOUND SYSTEMS							
PU-COMP-MIXED-001	5		5		5		Unreflected Slabs of Polystyrene-Moderated Plutonium Oxide
PU-COMP-MIXED-002	29		4		4		Plexiglas Reflected Slabs of Polystyrene-Moderated Plutonium Oxide
Pu SOLUTION SYSTEMS							
INTERMEDIATE ENERGY Pu SOLUTION SYSTEMS							
none presently evaluated							
THERMAL ENERGY Pu SOLUTION SYSTEMS							
PU-SOL-THERM-001	6		6		6		Water Reflected 11.5" Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-002	7		7		7		Water Reflected 12" Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-003	8		8		8		Water Reflected 13" Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-004	13		13		13		Water Reflected 14" Diameter Spheres of Pu Nitrate Solutions, 0.54% to 3.43%
PU-SOL-THERM-005	9		9		9		Water Reflected 14" Diameter Spheres of Pu Nitrate Solutions, 4.05% and 4.4%
PU-SOL-THERM-006	3		3		3		Water Reflected 15" Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-007	8		8		8		Water Reflected 11.5" Diameter Spheres Partly Filled with Pu Nitrate Solutions
PU-SOL-THERM-008	29						Concrete-Reflected 14-Inch Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-009	3		3		3		Unreflected 48" Diameter Sphere of Pu Nitrate Solution
PU-SOL-THERM-010	14		14		14		Water Reflected 9", 10", 11", and 12" Diameter Cylinders of Pu Nitrate Solutions
PU-SOL-THERM-011	12		12		12		Bare 16" and 18" Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-012	23						Pu Nitrate Soln in a Large Water Reflected Cubic Tank (130x130x100 cm) (19% ^{240}Pu)
PU-SOL-THERM-013	21						Interacting Cylinders of 256-mm Diameter with Pu Nitrate Solution (115.1 gPu/l) in Air

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
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PU-SOL-THERM-014	35		34		34		Interacting Cylinders of 300-mm Diameter with Pu Nitrate Solution (115.1 gPu/l) in Air
PU-SOL-THERM-015	17		17		17		Interacting Cylinders of 300-mm Diameter with Pu Nitrate Solution (152.5 gPu/l) in Air
PU-SOL-THERM-016	11		11		11		Interacting Cyls of 300-mm and 256-mm Dia with Pu Nitrate Soln (152.5 and 115.1 gPu/l) in Air
PU-SOL-THERM-017	18		18		18		Interacting Cyls of 256-mm and 300-mm Dia with Pu Nitrate Soln (115.1 gPu/l) in Air
PU-SOL-THERM-020	8		8		8		Water-reflected and Water-cadmium-reflected 14" Diameter Spheres of Pu Nitrate Soln
PU-SOL-THERM-021	6		4		4		Water-Reflected and Bare 15.2" Diameter Spheres of Pu Nitrate Solutions
PU-SOL-THERM-022	17						Pu (19% ^{240}Pu) Nitrate Soln in a Water-Refl Annular Cylinder Tank (50/20 cm Diameter)
PU-SOL-THERM-023	34						Pu (33.89% and 4.23% ^{240}Pu) Nitrate Soln in Two Water-Refl Cylindric Concentric Tanks
PU-SOL-THERM-024	23		23		23		slabs of Pu nitrate solutions reflected by 1-inch thick plexiglas
PU-SOL-THERM-025	44						water reflected slabs of Pu nitrate solutions
PU-SOL-THERM-026	21						unreflected slabs of Pu nitrate solutions

MIXED ENERGY Pu SOLUTION SYSTEMS

none presently evaluated

MISCELLANEOUS Pu SYSTEMS

FAST ENERGY MISCELLANEOUS Pu SYSTEMS

none presently evaluated

INTERMEDIATE ENERGY MISCELLANEOUS Pu SYSTEMS

none presently evaluated

THERMAL ENERGY MISCELLANEOUS Pu

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
SYSTEMS							
none presently evaluated							
MIXED ENERGY MISCELLANEOUS Pu SYSTEMS							
none presently evaluated							
Volume II, Highly Enriched Uranium Systems							
HEU METAL SYSTEMS							
FAST ENERGY HEU METAL SYSTEMS							
HEU-MET-FAST-001	1	1			1	2	bare sphere of U(93.71) metal (Godiva)
HEU-MET-FAST-002	6	6			6	6	U(nat) refl U(93.5) pseudosphere, pseudocylinder, sphere
HEU-MET-FAST-003	10	10			10	12	U(93.5) sphere refl by U(nat), Tungsten Carbide, or Ni
HEU-MET-FAST-004	1	1			1	1	U(97.67) sphere refl by water
HEU-MET-FAST-005	6					6	Be- or Mo-refl cyl assemblies of U(90) alloy with 3.3% Mo
HEU-MET-FAST-006	0	n/a	n/a			n/a	refer to HEU-MET-THERM-003
HEU-MET-FAST-007	43	43			43	42	U(93.15) slabs interleaved with poly, plexiglas, or teflon
HEU-MET-FAST-008	1					1	bare U(90) sphere
HEU-MET-FAST-009	2					2	U(90) sphere refl by Be or BeO
HEU-MET-FAST-010	2					2	U(90) sphere refl by B+Be or B+BeO
HEU-MET-FAST-011	1					1	U(90) sphere refl by poly
HEU-MET-FAST-012	1					1	Al refl spherical assembly of U(90) metal
HEU-MET-FAST-013	1					1	steel refl spherical assembly of U(90) metal
HEU-MET-FAST-014	1					1	U(dep) refl spherical assembly of U(90) metal
HEU-MET-FAST-015	1			1	1	1	bare cylindrical assembly of U(90) metal
HEU-MET-FAST-016	2			2	2	2	Be- or BeO-refl cylindrical assembly of U(90) metal
HEU-MET-FAST-017	1			1	1	1	Be-refl cylindrical assembly of U(90) metal interleaved with Be
HEU-MET-FAST-018	1	1			1	1	bare spherical assembly of U(90) metal
HEU-MET-FAST-019	1	1			1	1	graphite refl spherical assembly of U(90) metal

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HEU-MET-FAST-020	1	1			1		poly refl spherical assembly of U(90) metal
HEU-MET-FAST-021	1	1			1	1	steel refl spherical assembly of U(90) metal
HEU-MET-FAST-022	1	1			1	1	duralumin refl spherical assembly of U(90) metal
HEU-MET-FAST-023	22	2			2	1	Tinkertoy arrays of 10.5 kg U(93.2) cyl
HEU-MET-FAST-024	1					1	spherical assembly of U(90) metal refl by thin steel and thick poly
HEU-MET-FAST-026	32	5			5	32	Tinkertoy arrays of 15, 20, and 25 kg U(93.2) cyl
HEU-MET-FAST-027	1	1			1	1	Pb refl spherical assembly of U(90) metal
HEU-MET-FAST-028	1	1			1	1	U(93.24) sphere refl by U(nat)
HEU-MET-FAST-029	1	1			1		U(dep) refl spherical assembly of U(90) metal
HEU-MET-FAST-030	1	1			1	1	U(dep) refl cyl assemblies of U(96) metal discs interleaved with Be
HEU-MET-FAST-031	1	1			1	1	poly refl spherical shell of U(90) metal with central cavity ofpoly
HEU-MET-FAST-032	4	4			4	4	U(nat) refl spherical assemblies of U(94) metal
HEU-MET-FAST-033	2			2	2	2	unrefl cyl assemblies of U(96) metal discs interleaved with poly and steel
HEU-MET-FAST-034	3	3			3	3	unrefl cyl assemblies of U(96) metal discs interleaved with poly and Ti, Al, or steel
HEU-MET-FAST-035	0	n/a	n/a			n/a	deleted and republished as HEU-MET-INTER-001
HEU-MET-FAST-036	2			2	2	2	unrefl cyl assemblies of U(96) metal discs interleaved with poly and U(dep)
HEU-MET-FAST-037	2			2	2	2	poly refl cyl assemblies of U(96) metal discs interleaved with poly and U(dep)
HEU-MET-FAST-038	1			1	1	1	U(dep) refl cyl assembly of U(96) metal discs interleaved with Be and BeO
HEU-MET-FAST-039	0	n/a	n/a			n/a	unrefl and steel refl U(93.2) spherical and hemispherical assemblies
HEU-MET-FAST-041	6			6	6	6	Be- or graphite-refl spherical assemblies of U(94) metal
HEU-MET-FAST-048	17					17	oil refl U(93.2) spherical and hemispherical assemblies with oil,steel, or void cores
HEU-MET-FAST-051	18						unmod & unrefl U(93.2) metal cylinders as individual units and interacting pairs

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
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HEU-MET-FAST-055	4			4	4	1	cylindrical honeycomb assembly with a U(93.2)+Al core and U(dep) refl
HEU-MET-FAST-060	1						cyl honeycomb assy with a U(93)-W core with an Al reflector (ZPR-9/4)
HEU-MET-FAST-061	1					1	cyl honeycomb assy with a U(93.2)+U(dep)+Zr+SS core and graphite refl
HEU-MET-FAST-062	1					1	CORAL-I: a cylindrical assembly of U(89.7) with U(nat) refl
HEU-MET-FAST-068	2						cyl assy with a U(90)-Th-Poly core with U(dep)O_2 refl (KBR-22 and KBR-23)
INTERMEDIATE ENERGY HEU METAL SYSTEMS							
HEU-MET-INTER-001	1			1	1	1	cylindrical ZPR assembly with a U(93.2)-Fe core and stainless steel refl
HEU-MET-INTER-002	0	n/a	n/a			n/a	refer to HEU-MET-FAST-034
HEU-MET-INTER-003	0	n/a	n/a			n/a	refer to HEU-MET-FAST-030
HEU-MET-INTER-004	0	n/a	n/a			n/a	refer to HEU-MET-MIXED-004
HEU-MET-INTER-005	0	n/a	n/a			n/a	refer to HEU-MET-MIXED-005
HEU-MET-INTER-006	3			3	3	2	ZEUS: Cu refl cyl assembly of U(93.2) metal plates interleaved with graphite plates
HEU-MET-INTER-007	0	n/a	n/a			n/a	refer to HEU-MET-FAST-007
THERMAL ENERGY HEU METAL SYSTEMS							
HEU-MET-THERM-001	1			1	1		U(93) metal foils interleaved with plates of SiO_2 glass and poly with poly refl
HEU-MET-THERM-002	0	n/a	n/a			n/a	Be-refl Honeycomb assemblies of U(93) foils moderated by graphite
HEU-MET-THERM-003	7	7			7	4	lattices of U(94) cubes immersed in water
HEU-MET-THERM-005	0	n/a	n/a			n/a	refer to HEU-MET-MIXED-005

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HEU-MET-THERM-006	23	23			23	3	SPERT-D elements [assemblies of U(93)-Al alloy plates] in H_2O, dilute UNH, or borated UNH
HEU-MET-THERM-007	11						SPERT-III type 1S elements [assemblies of U(93.2)O_2 impregnated SS plates] in H_2O
HEU-MET-THERM-008	1						U(93) metal foils interleaved with plates of Al and poly with poly refl
HEU-MET-THERM-009	1						U(93) metal foils interleaved with MgO and poly with poly refl
HEU-MET-THERM-010	1						U(93) metal foils interleaved with plates of Gd and poly with poly refl
HEU-MET-THERM-011	43						U(93)-Al alloy plates immersed in water
MIXED ENERGY HEU METAL SYSTEMS							
HEU-MET-MIXED-001	1	1			1	1	poly refl cyl assemblies of U(96) metal discs interleaved with poly and Ti
HEU-MET-MIXED-002	1	1			1	1	poly refl spherical shell of U(90) metal with central cavity of poly
HEU-MET-MIXED-003	1	1			1	1	poly refl spherical shell of U(90) metal with central cavity of poly
HEU-MET-MIXED-004	1					1	U(dep) refl cyl assemblies of U(96) metal discs interleaved with poly and U(dep)
HEU-MET-MIXED-005	5						large, heterogeneous core assemblies of tubes containing U(89.4) + SiO2 + poly
HEU-MET-MIXED-006	0	n/a	n/a			n/a	refer to HEU-MET-FAST-033
HEU-MET-MIXED-007	0	n/a	n/a			n/a	refer to HEU-MET-FAST-036
HEU-MET-MIXED-008	0	n/a	n/a			n/a	refer to HEU-MET-FAST-037
HEU-MET-MIXED-009	0	n/a	n/a			n/a	refer to HEU-MET-FAST-007
HEU-MET-MIXED-010	0	n/a	n/a			n/a	refer to HEU-MET-THERM-003
HEU COMPOUND SYSTEMS							
FAST ENERGY HEU COMPOUND SYSTEMS							
HEU-COMP-FAST-001	0	n/a	n/a			n/a	refer to HEU-COMP-MIXED-001
HEU-COMP-FAST-003	0	n/a	n/a			n/a	refer to HEU-COMP-MIXED-002
INTERMEDIATE ENERGY HEU COMPOUND SYSTEMS							

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
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HEU-COMP-INTER-001	0						deleted and republished as HEU-COMP-MIXED-003
HEU-COMP-INTER-002	0						deleted and republished as HEU-COMP-MIXED-004
HEU-COMP-INTER-003	7			7	7	7	cyl assemblies of canned U(90.7)H_8 disks refl by U(dep), Be, and/or Fe
HEU-COMP-INTER-004	1			1	1	1	k-inf measurements for a homogenous U(92)O_2-graphite-Ca metaborate system
HEU-COMP-INTER-005	5			4	4	5	k-inf measurements for a U(90)O_2 and Ni, SS, SS+Mo, Cr, or Zr system
HEU-COMP-INTER-006	0	n/a	n/a			n/a	refer to HEU-COMP-MIXED-002
THERMAL ENERGY HEU COMPOUND SYSTEMS							
HEU-COMP-THERM-001	0	n/a	n/a			n/a	refer to HEU-COMP-MIXED-001
HEU-COMP-THERM-002	25					25	arrays of hexagonal U(93)-graphite rods (ROVER) immersed in water
HEU-COMP-THERM-003	15					15	two-zone arrays of cross-shaped U(80)O_2-Cu rods immersed in water
HEU-COMP-THERM-004	4					4	arrays of cross-shaped U(90)O_2-Cu rods immersed in water with Gd or Sm rods
HEU-COMP-THERM-005	1					1	clusters of arrays of cross-shaped U(80)O_2-Cu rods immersed in water
HEU-COMP-THERM-006	3					3	arrays of cross-shaped U(80)O_2-Cu rods immersed in water
HEU-COMP-THERM-007	3					3	arrays of cross-shaped U(80)O_2-Cu rods immersed in water with Zr-hydride rods
HEU-COMP-THERM-008	2						arrays of cross-shaped U(80)O_2-Cu rods immersed in water with B_4C rods
HEU-COMP-THERM-010	21	6			6	21	arrays of U(62.4)O_2-BeO rods immersed in water, U(92.6)NH, and/or boric acid
HEU-COMP-THERM-011	3	3			3	3	clusters of 21x21 lattices of U(80)O_2-Al rods immersed in water
HEU-COMP-THERM-012	2	2			2	2	clusters of 18x18 lattices of U(80)O_2-Al rods immersed in water
HEU-COMP-THERM-013	2	2			2	2	clusters of 14x14 lattices of U(80)O_2-Al rods immersed in water
HEU-COMP-THERM-014	2	2			2	2	clusters of 10x10 lattices of U(80)O_2-Al rods immersed in water
HEU-COMP-THERM-015	0	n/a	n/a			n/a	deleted and republished as HEU-COMP-MIXED-002
HEU-COMP-THERM-016	6						graphite refl U(89.3)-graphite blocks (C/X~8180) with Gd_2O_3-graphite control rods
HEU-COMP-THERM-017	9			9	9		lattices of annular cyl U(80)O_2-Al rods immersed in D_2O
INTERMEDIATE ENERGY HEU COMPOUND SYSTEMS							
none presently evaluated							

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MIXED ENERGY HEU COMPOUND SYSTEMS							
HEU-COMP-MIXED-001	26	7		2	9		arrays of cans of wet or dry $U(93)O_2$ powder with poly refl
HEU-COMP-MIXED-002	23						cans of $U(90)O_2$ powder arrayed and immersed in water or D_2O
HEU-COMP-MIXED-003	6						Be-refl Rx core assemblies of $U(96)O_2$ and Zr-hydride immersed in water
HEU-COMP-MIXED-004	5						Be-refl Rx core assemblies of $U(96)O_2$ and Zr-hydride immersed in sand/water
HEU SOLUTION SYSTEMS							
INTERMEDIATE ENERGY HEU SOLUTION SYSTEMS							
HEU-SOL-INTER-001	0	n/a	n/a			n/a	refer to HEU-SOL-THERM-004 and HEU-SOL-THERM-020
HEU-SOL-INTER-002	0	n/a	n/a			n/a	refer to HEU-SOL-THERM-039
THERMAL ENERGY HEU SOLUTION SYSTEMS							
HEU-SOL-THERM-001	10	10			10	10	U(93.2)NH soln in cyl geom, 50-360 gU/l, minimal refl
HEU-SOL-THERM-002	14	14			14	14	U(93.2)NH soln in cyl geom, 60-335 gU/l, concrete refl
HEU-SOL-THERM-003	19	19			19	19	U(93.2)NH soln in cyl geom, 60-345 gU/l, Plexiglas refl
HEU-SOL-THERM-004	6	6			6	6	$U(93.65)O_2F_2$ in D_2O soln in sph geom, D/X from 34 to 430, D_2O refl
HEU-SOL-THERM-005	17	8			8		Pyrex glass poisoned $U(87.4)NH$ or $U(93.2)O_2F_2$ soln in cyl geom, varied H_2O refl
HEU-SOL-THERM-006	29	7			7		boric acid poisoned U(93)NH soln in cyl geom, 295 gU/l, various refl combinations
HEU-SOL-THERM-007	17	17			17	5	concrete refl arrays of U(93.2)NH soln cylinders, 67-370 gU/l
HEU-SOL-THERM-008	14	14			14	14	Plexiglas refl arrays of U(93.2)NH soln cylinders, 60-356 gU/l
HEU-SOL-THERM-009	4	4			4	4	$U(93.2)O_2F_2$ soln in 6.4 liter sph geom, 213-696 gU/l, water refl
HEU-SOL-THERM-010	4	4			4	4	$U(93.2)O_2F_2$ soln in 9.7 liter sph geom, 95-107 gU/l, water refl
HEU-SOL-THERM-011	2	2			2	2	$U(93.2)O_2F_2$ soln in 17 liter sph geom, 48-50 gU/l, water refl
HEU-SOL-THERM-012	1	1			1		$U(93.2)O_2F_2$ soln in 91 liter sph geom, 20.5 gU/l, water refl
HEU-SOL-THERM-013	4	4			4	4	boric acid poisoned U(93.2)NH soln in 174 liter sph geom, 20-28 gU/l, unrefl
HEU-SOL-THERM-014	3	3			3	3	Gd poisoned U(89)NH soln in cyl geom, ~70 gU/l, water refl
HEU-SOL-THERM-015	5	5			5	5	Gd poisoned U(89)NH soln in cyl geom, ~100 gU/l, water refl

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HEU-SOL-THERM-016	3	3			3	3	Gd poisoned U(89)NH soln in cyl geom, ~150 gU/l, water refl
HEU-SOL-THERM-017	8	8			8	8	Gd poisoned U(89)NH soln in cyl geom, ~200 gU/l, water refl
HEU-SOL-THERM-018	12	12			12	12	Gd poisoned U(89)NH soln in cyl geom, ~300 gU/l, water refl
HEU-SOL-THERM-019	3	3			3	3	Gd poisoned U(89)NH soln in cyl geom, ~400 gU/l, water refl
HEU-SOL-THERM-020	5	5			5	5	U(93.65)O_2F_2 in D_2O soln in sph geom, D/X from 230 to 2080, unrefl
HEU-SOL-THERM-021	32	6		4	10		bare and hydrogenous refl arrays of U(93.2)NH soln cylinders, 63-415 gU/l
HEU-SOL-THERM-022	1						intersection of two steel pipes containing U(89)NH soln, 141 gU/l, water refl
HEU-SOL-THERM-023	1						steel pipe intersections containing U(89)NH soln, 408 gU/l, water refl
HEU-SOL-THERM-024	14					14	steel pipe intersections containing U(89)NH soln, 64-386 gU/l, bare and water refl
HEU-SOL-THERM-025	18	18			18	18	Gd poisoned U(89)NH soln in cyl geom, 48-400 gU/l, water refl
HEU-SOL-THERM-027	9	9			9	9	unrefl U(89)NH soln in cyl geom, 136 gU/l, central rod of B_4C, Cd, or n/a
HEU-SOL-THERM-028	18	18			18	18	water refl U(89)NH soln in cyl geom, 76 or 286 gU/l, central rod of B_4C or n/a
HEU-SOL-THERM-029	7	7			7	7	water refl U(89)NH soln in cyl geom, 286 gU/l, seven rods of B_4C or n/a
HEU-SOL-THERM-030	7	7			7	7	water refl U(89)NH soln in cyl geom, 76 or 286 gU/l, 3-6 rods of B_4C or n/a
HEU-SOL-THERM-031	4	4			4		water refl U(89)NH soln in cyl geom, 286 gU/l, 18 or 36 rods of B_4C
HEU-SOL-THERM-032	1	1			1		U(93.2)NH soln in 48" dia. sph geom, ~15 gU/l, unrefl
HEU-SOL-THERM-033	26	26			26	26	ann cyl tanks of U(93.2)NH soln, 357 gU/l, cavity of varius matls, concrete refl
HEU-SOL-THERM-035	9	9			9	9	water refl U(89)NH soln in cyl geom, 37-152 gU/l, multiple rods of B_4C or n/a
HEU-SOL-THERM-036	4	4			4	4	unrefl U(89)NH soln in cuboidal geom, 92.7 gU/l, multiple rods of B_4C or n/a
HEU-SOL-THERM-037	9	9			9	9	water refl U(89)NH soln in cyl geom, 42-83 gU/l, multiple rods of B_4C or n/a
HEU-SOL-THERM-038	30						U(93)NH soln @ 404 gU/l in two cyl slab tanks, mod/refl by H, B, Be, Pb, SS, Cd, or U(dep)
HEU-SOL-THERM-039	6					6	liquid U(93.2)F_6+HF at low H/U (9.9 to 82) in a spherical tank with hot water reflection
HEU-SOL-THERM-040	17						U(93)NH soln @ 453 gU/l in unreflected intersecting pipe configurations
HEU-SOL-THERM-042	8					8	unreflected 5-ft or 9-ft diameter cylinders of U(93.2)NH soln @ 13.6 to 17.3 gU/l

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
HEU-SOL-THERM-043	3					3	17-, 91-, or 174-liter U(93.2)O_2F_2 soln in sph geom @ 134-, 25-, or 20-gU/l, unrefl
HEU-SOL-THERM-044	31						concrete refl U(93.2)NH soln cyl @ 363 gU/l, cyl geom w/per dist of neut abs rods
HEU-SOL-THERM-045	0	n/a	n/a			n/a	"Tuck and Clark" interacting U(93.2)NH slab-cylinder experiments
SUB-HEU-SOL-THERM-001	5						^{252}Cf-driven noise measurements of unrefl U(93.2)NH soln @ 482 gU/l in cyl geom
MIXED ENERGY HEU SOLUTION SYSTEMS							
none presently evaluated							
MISCELLANEOUS HEU SYSTEMS							
FAST ENERGY MISCELLANEOUS HEU SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY MISCELLANEOUS HEU SYSTEMS							
none presently evaluated							
THERMAL ENERGY MISCELLANEOUS HEU SYSTEMS							
HEU-MISC-THERM-001	0	n/a	n/a			n/a	refer to HEU-MET-THERM-006
HEU-MISC-THERM-002	0	n/a	n/a			n/a	refer to HEU-COMP-THERM-010
MIXED ENERGY MISCELLANEOUS HEU SYSTEMS							
none presently evaluated							
Volume III, Intermediate and Mixed Enrichment Uranium Systems							
IEU METAL SYSTEMS							
FAST ENERGY IEU METAL SYSTEMS							
IEU-MET-FAST-001	4			4	4	4	unrefl cyl U(93.4) metal discs interleaved with U(nat), effectively U(36) or U(55)

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
IEU-MET-FAST-002	1			1	1	1	U(nat) refl cyl U(93.4) metal discs interleaved with U(nat), effectively U(16)
IEU-MET-FAST-003	1			1	1	1	bare spherical assembly of U(36) metal
IEU-MET-FAST-004	1			1	1	1	graphite refl spherical assembly of U(36) metal
IEU-MET-FAST-005	1			1	1	1	steel refl spherical assembly of U(36) metal
IEU-MET-FAST-006	1			1	1	1	Al refl spherical assembly of U(36) metal
IEU-MET-FAST-007	1			1	1	1	cyl assembly of U(93), U(10), and U(nat) metal, effectively U(10) core, U(dep) refl
IEU-MET-FAST-008	1			1	1	1	U(dep) refl spherical assembly of U(36) metal
IEU-MET-FAST-009	1			1	1	1	poly refl spherical assembly of U(36) metal
IEU-MET-FAST-010	1			1	1	1	cyl ZPR assembly with a U(93)+U(dep) core [effectively U(9)] with U(dep) refl
IEU-MET-FAST-012	1			1	1	1	cyl ZPR assembly with a U(93)+U(dep)+Al+Fe core with U(dep) refl (ZPR-3/41)
IEU-MET-FAST-014	2			2	2		cyl ZPR assembly with a U(93)+U(dep)+W metal core with Al refl (ZPR-9/2 and 3)
INTERMEDIATE ENERGY IEU METAL SYSTEMS							
none presently evaluated							
THERMAL ENERGY IEU METAL SYSTEMS							
none presently evaluated							
MIXED ENERGY IEU METAL SYSTEMS							
none presently evaluated							
IEU COMPOUND SYSTEMS							
FAST ENERGY IEU COMPOUND SYSTEMS							
IEU-COMP-FAST-002	0	n/a	n/a			n/a	refer to IEU-COMP-INTER-001

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
INTERMEDIATE ENERGY IEU COMPOUND SYSTEMS							
IEU-COMP-INTER-001	4			4	4		k-inf measurements for tube assemblies of $U(93)O_2$+$U(36)O_2$+Th+poly
THERMAL ENERGY IEU COMPOUND SYSTEMS							
IEU-COMP-THERM-001	29			29	29	21	arrays of $U(30)F_4$-polytetrafluoroethylene and polyethylene cubes
IEU-COMP-THERM-002	6					6	latticed annular $U(17)O_2$ rods in H_2O, annuli of H_2O, Gd_2O_3-Al_2O_3, or CdO-Al_2O_3
IEU-COMP-THERM-003	2			2	2	2	lattices of cyl U(20)-Zr-hydride rods in H_2O, graphite refl
IEU-COMP-THERM-005	0	n/a	n/a			n/a	refer to IEU-COMP-INTER-001
MIXED ENERGY IEU COMPOUND SYSTEMS							
none presently evaluated							
IEU SOLUTION SYSTEMS							
THERMAL ENERGY IEU SOLUTION SYSTEMS							
IEU-SOL-THERM-001	4						$U(20.9)O_2SO_4$ soln in cyl geom, 263-505 gU/l, graphite refl
MISCELLANEOUS IEU SYSTEMS							
FAST ENERGY MISCELLANEOUS IEU SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY MISCELLANEOUS IEU SYSTEMS							
none presently evaluated							
THERMAL ENERGY MISCELLANEOUS IEU SYSTEMS							
none presently evaluated							

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
MIXED ENERGY MISCELLANEOUS IEU SYSTEMS							
none presently evaluated							
Volume IV, Low Enriched Uranium Systems							
LEU METAL SYSTEMS							
FAST ENERGY LEU METAL SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY LEU METAL SYSTEMS							
none presently evaluated							
THERMAL ENERGY LEU METAL SYSTEMS							
LEU-MET-THERM-001	1			1	1		lattice of cyl U(nat) metal rods immersed in D_2O
LEU-MET-THERM-002	12			12	12		lattices of annular cyl U(2) metal rods immersed in D_2O
MIXED ENERGY LEU METAL SYSTEMS							
none presently evaluated							
LEU COMPOUND SYSTEMS							
FAST ENERGY LEU COMPOUND SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY LEU COMPOUND SYSTEMS							
none presently evaluated							
THERMAL ENERGY LEU COMPOUND SYSTEMS							
LEU-COMP-THERM-001	8	8			8		lattices of cyl U(2.35)O_2 rods immersed in water

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
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LEU-COMP-THERM-002	5	5			5		lattices of cyl U(4.31)O_2 rods immersed in water
LEU-COMP-THERM-003	23	22			22		lattices of cyl U(2.35)O_2 rods immersed in water, water contains Gd impurity
LEU-COMP-THERM-004	20	20			20		lattices of cyl U(4.31)O_2 rods immersed in water, water contains Gd impurity
LEU-COMP-THERM-005	16						lattices of cyl U(2.35)O_2 or U(4.31)O_2 rods immersed in water containing Gd
LEU-COMP-THERM-006	18						lattices of cyl U(2.6)O_2 rods immersed in water
LEU-COMP-THERM-007	10						lattices of cyl U(4.738)O_2 rods immersed in water
LEU-COMP-THERM-008	17			1	1		U(2.459)O_2 rods latticed in borated H_2O, pertubed by Vicor, Pyrex, or Al_2O_3 rods
LEU-COMP-THERM-009	27			1	1		clusters of U(4.31)O_2 rods in water purturbed by various matls as plates
LEU-COMP-THERM-010	30						lattices of U(4.31)O_2 rods in water refl by two Pb, U(dep), or steel walls
LEU-COMP-THERM-011	15						clusters of U(2.5)O_2 rods immersed in water, poisoned with B_4C rods or borated water
LEU-COMP-THERM-012	10			10	10		clusters of U(2.35)O_2 rods in H_2O (Gd impurity) purturbed by various matls as plates
LEU-COMP-THERM-013	7						clusters of U(4.31)O_2 rods in water poisoned by various matls as plates
LEU-COMP-THERM-014	5						water reflected arrays of U(4.31)O_2 fuel rods in borated water
LEU-COMP-THERM-015	165						VVER Experiments, Part I
LEU-COMP-THERM-016	32	32			32		clusters of U(2.35)O_2 rods in water purturbed by various matls as plates
LEU-COMP-THERM-017	29						lattices of U(2.35)O_2 rods in water refl by two Pb, U(dep), or steel walls
LEU-COMP-THERM-018	1						U(7)O_2 rods immersed in water
LEU-COMP-THERM-019	3						stainless steel clad U(5)O_2 rods immersed in water
LEU-COMP-THERM-020	7						Zr-clad U(5)O_2 rods immersed in water
LEU-COMP-THERM-021	6						Zr-clad U(5)O_2 rods immersed in borated water
LEU-COMP-THERM-022	7						stainless steel clad U(10)O_2 rods immersed in water
LEU-COMP-THERM-023	6						stainless steel clad U(10)O_2 rods immersed in water
LEU-COMP-THERM-024	2						stainless steel clad U(10)O_2 rods immersed in water
LEU-COMP-THERM-025	4						stainless steel clad U(7.5)O_2 rods immersed in water
LEU-COMP-THERM-026	6						Zr-clad U(4.92)O_2 rods immersed in water at varied temperatures
LEU-COMP-THERM-027	4						Al-clad U(4.74)O_2 rods immersed in water, Pb refl

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LEU-COMP-THERM-029	12						Al-clad U(4.74)O_2 rods immersed in water surrounded by Hf plates
LEU-COMP-THERM-031	6						Zr-clad U(5)O_2 rods immersed in water
LEU-COMP-THERM-032	9						stainless steel clad U(10)O_2 rods immersed in water at varied temperatures
LEU-COMP-THERM-033	52						unrefl and hydrogenous refl cores of UF_4-paraffin cuboids at 2 or 3% enrichment
LEU-COMP-THERM-034	24						U(4.738)O_2 rod clusters in Cd, bor-ss, or Boral cannisters and immersed in H_2O
LEU-COMP-THERM-035	3						U(2.6)O_2 rods immersed in Gd- or B-poisoned water
LEU-COMP-THERM-036	69						VVER Experiments, Part II
LEU-COMP-THERM-037	11						U(4.738)O_2 rods immersed in water, partial refl by concrete
LEU-COMP-THERM-038	14						U(4.738)O_2 rods immersed in water, partial refl by borated concrete
LEU-COMP-THERM-039	17						incomplete/irregular lattices of U(4.738)O_2 rods immersed in water
LEU-COMP-THERM-040	10						U(4.738)O_2 rod clusters in Cd, bor-ss, or Boral cannisters in water, Pb or steel refl
LEU-COMP-THERM-041	5						HEU driven U(3)O_2 rod clusters in water separated by ss, bor-ss, or Cd plates
LEU-COMP-THERM-042	7						U(2.35)O_2 rod clusters in H_2O separated by various matls as plates, refl by steel walls
LEU-COMP-THERM-047	3						lattices of cyl U(3)O_2 and/or U(7)O_2 rods immersed in water
LEU-COMP-THERM-048	5						lattices of cyl U(3)O_2 rods immersed in water
LEU-COMP-THERM-049	18						poly refl split-table arrays of cuboidal cans containing U(5)O2 powder at low H/U
LEU-COMP-THERM-050	18						H_2O immersion of U(4.738)O_2 rods arround a sq tank of ^{149}Sm, B, or H2O in soln
LEU-COMP-THERM-051	19						clusters of U(2.5)O_2 rods immersed in borated water, poisoned with SS or Boral plates
LEU-COMP-THERM-052	6						lattices of U(4.738)O_2 or rods immersed in Gd-nitrate soln
LEU-COMP-THERM-055	2						water reflected and water moderated U(3)O_2 rod lattices

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
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LEU-COMP-THERM-061	10						VVER-type fuel assemblies immersed in water, perturbed with B_4C, Hf, Dy, or gaps
LEU-COMP-THERM-062	15						$U(2.6)O_2$ rod lattices immersed in water, perturbed with borated SS plates
SUB-LEU-COMP-THERM-001	15						lattices of cyl $U(3)O_2$ rods immersed in water and compartmentalized by borated steel
MIXED ENERGY LEU COMPOUND SYSTEMS							
none presently evaluated							
LEU SOLUTION SYSTEMS							
THERMAL ENERGY LEU SOLUTION SYSTEMS							
LEU-SOL-THERM-001	1						unreflected $U(5)O_2F_2$ soln in cyl geom, 1000 gU/l
LEU-SOL-THERM-002	3						$U(4.9)O_2F_2$ soln in 147 liter sph geom, ~450 or ~490 gU/l, unrefl or water refl
LEU-SOL-THERM-003	9	9			9		full and truncated spheres of U(10)NH soln
LEU-SOL-THERM-004	7						STACY: water refl U(10)NH soln in cyl geom, ~225-310 gU/l
LEU-SOL-THERM-005	3			7	7		water refl U(5.64)NH soln in cyl geom, ~400 gU/l, with or without B_4C rods
LEU-SOL-THERM-006	5						water refl U(10)NH soln in cyl geom, ~420 gU/l, with or without B_4C rods
LEU-SOL-THERM-007	5						STACY: unreflected U(10)NH soln in cyl geom, ~242-313 gU/l
LEU-SOL-THERM-008	4						STACY: concrete refl U(10)NH soln in cyl geom, ~240 gU/l
LEU-SOL-THERM-009	3						STACY: borated concrete refl U(10)NH soln in cyl geom, ~240 gU/l
LEU-SOL-THERM-010	4						STACY: poly refl U(10)NH soln in cyl geom, ~240 gU/l
LEU-SOL-THERM-016	7						STACY: water refl U(10)NH soln in slab geom, ~300-464 gU/l
LEU-SOL-THERM-017	6						STACY: unreflected U(10)NH soln in slab geom, ~315-464 gU/l
LEU-SOL-THERM-018	6						STACY: concrete refl U(10)NH soln in slab geom, ~310-315 gU/l
LEU-SOL-THERM-019	6						STACY: poly refl U(10)NH soln in slab geom, ~320 gU/l
LEU-SOL-THERM-020	4						STACY: water refl U(10)NH soln in cyl geom, ~194-243 gU/l
LEU-SOL-THERM-021	4						STACY: unreflected U(10)NH soln in cyl geom, ~194-243 gU/l

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LEU-SOL-THERM-022	4						STACY: borated concrete refl U(10)NH soln in slab geom, ~310 gU/l
MISCELLANEOUS LEU SYSTEMS							
FAST ENERGY MISCELLANEOUS LEU SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY MISCELLANEOUS LEU SYSTEMS							
none presently evaluated							
THERMAL ENERGY MISCELLANEOUS LEU SYSTEMS							
none presently evaluated							
MIXED ENERGY MISCELLANOUS LEU SYSTEMS							
none presently evaluated							
Volume V, Uranium-233 Systems							
U-233 METAL SYSTEMS							
FAST ENERGY U-233 METAL SYSTEMS							
U233-MET-FAST-001	1			1	1		bare sphere of U-233 metal (U-233 Jezebel)
U233-MET-FAST-002	2			2	2		10 kg or 7.6 kg U-233 metal sphere reflected by U(93) metal
U233-MET-FAST-003	2			2	2		10 kg or 7.6 kg U-233 metal sphere reflected by U(nat) metal
U233-MET-FAST-004	2			2	2		10 kg or 7.6 kg U-233 metal sphere reflected by W metal
U233-MET-FAST-005	2			2	2		10 kg or 7.6 kg U-233 metal sphere reflected by Be metal
U233-MET-FAST-006	1			1	1		U(nat) reflected sphere of U-233 metal (U-233 Flattop)
INTERMEDIATE ENERGY U-233 METAL SYSTEMS							
none presently evaluated							

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
THERMAL ENERGY U-233 METAL SYSTEMS							
none presently evaluated							
MIXED ENERGY U-233 METAL SYSTEMS							
none presently evaluated							
U-233 COMPOUND SYSTEMS							
FAST ENERGY U-233 COMPOUND SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY U-233 COMPOUND SYSTEMS							
none presently evaluated							
THERMAL ENERGY U-233 COMPOUND SYSTEMS							
none presently evaluated							
MIXED ENERGY U-233 COMPOUND SYSTEMS							
none presently evaluated							
U-233 SOLUTION SYSTEMS							
INTERMEDIATE ENERGY U-233 SOLUTION SYSTEMS							
U233-SOL-INTER-001	33			33	33		$^{233}UO_2F_2$ soln in spherical geometry with Be, poly, or Be-poly reflectors
THERMAL ENERGY U-233 SOLUTION SYSTEMS							
U233-SOL-THERM-001	5			5	5		unreflected spheres of ^{233}UNH solution with varied boron content
U233-SOL-THERM-002	17			17	17		paraffin reflected cylinders of ^{233}UNH solution

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
U233-SOL-THERM-003	10			1	1		paraffin reflected cylinders of $^{233}UO_2F_2$ solution
U233-SOL-THERM-004	8			8	8		paraffin reflected cylinders of ^{233}UNH solution
U233-SOL-THERM-005	2			2	2		water reflected cylinder or sphere of ^{233}UNH solution
U233-SOL-THERM-006	25			8	8		arrays of ^{233}UNH solution cylinders
U233-SOL-THERM-008	1			1	1		unreflected sphere of ^{233}UNH solution
U233-SOL-THERM-011	0	n/a	n/a			n/a	refer to U233-SOL-INTER-001
U233-SOL-THERM-012	8			8	8		water reflected spherical vessels containing ^{233}UNH solution
U233-SOL-THERM-014	16			16	16		arrays of polybottles containing ^{233}UNH solution
U233-SOL-THERM-015	31			31	31		$^{233}UO_2F_2$ soln in spherical geometry with Be, poly, or Be-poly reflectors
MIXED ENERGY U-233 SOLUTION SYSTEMS							
U233-SOL-MIXED-001	0	n/a	n/a			n/a	refer to U233-SOL-INTER-001
U233-SOL-MIXED-002	0	n/a	n/a			n/a	refer to U233-SOL-THERM-015

U-233 MISCELLANEOUS SYSTEMS

FAST ENERGY U-233 MISCELLANEOUS SYSTEMS

none presently evaluated

INTERMEDIATE ENERGY U-233 MISCELLANEOUS SYSTEMS

none presently evaluated

THERMAL ENERGY U-233 MISCELLANEOUS SYSTEMS

none presently evaluated

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
MIXED ENERGY U-233 MISCELLANEOUS SYSTEMS							
none presently evaluated							
Volume VI, Mixed Plutonium-Uranium Systems							
MIXED PU-U METAL SYSTEMS							
FAST ENERGY MIXED PU-U METAL SYSTEMS							
MIX-MET-FAST-001	1		1		1	1	sphere of ^{239}Pu metal (~4.9% ^{240}Pu) reflected by U(93.2) metal
MIX-MET-FAST-002	3		3		3	3	composite sph cores of ^{239}Pu (varied ^{240}Pu) and U(93.2) metal refl by U(nat) metal
MIX-MET-FAST-003	1					1	sphere of ^{239}Pu metal (~9% ^{240}Pu) reflected by U(89) metal
MIX-MET-FAST-004	2					2	composite sph cores of ^{239}Pu (~9% ^{240}Pu) and U(89) metal refl by Be and BeO
MIX-MET-FAST-005	1					1	composite sph core of ^{239}Pu (~9% ^{240}Pu) and U(89) metal refl by Al
MIX-MET-FAST-007	23		23		23	23	composite sph cores of ^{239}Pu (~5.7% ^{240}Pu) and U(93.2) metal refl by Be metal
MIX-MET-FAST-008	7					3	k-inf for ^{239}Pu, MOX, or U(37) plates interleaved with C, SST, Na, and/or U(nat) plates
MIX-MET-FAST-009	1		1		1	1	sph core of ^{239}Pu (~1.8% ^{240}Pu) metal reflected by 0.75-cm thick U(89) metal
MIX-MET-FAST-010	1		1		1	1	sph core of ^{239}Pu (~1.8% ^{240}Pu) metal reflected by 2.89-cm thick U(89) metal
MIX-MET-FAST-011	4		4		4	1	cyl assy of fissile Pu/U/Zr fuel plates reflected by graphite (ZPPR-9/21B thru 21E)
MIX-MET-FAST-012	0	n/a	n/a			n/a	refer to PU-MET-FAST-033
INTERMEDIATE ENERGY MIXED PU-U METAL SYSTEMS							
MIX-MET-INTER-001	0	n/a	n/a			n/a	refer to MIX-MET-FAST-008
MIX-MET-INTER-002	0	n/a	n/a			n/a	refer to MIX-MET-MIXED-001
THERMAL ENERGY MIXED PU-U METAL SYSTEMS							
none presently evaluated							
MIXED ENERGY MIXED PU-U METAL SYSTEMS							
MIX-MET-MIXED-001	1					1	unrefl cyl assy of alternating ^{239}Pu (~4.6% ^{240}Pu) metal, U(96) metal, and poly plates

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
MIXED PU-U COMPOUND SYSTEMS							
FAST ENERGY MIXED PU-U COMPOUND SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY MIXED PU-U COMPOUND SYSTEMS							
none presently evaluated							
THERMAL ENERGY MIXED PU-U COMPOUND SYSTEMS							
MIX-COMP-THERM-001	4						mixed $^{239}PuO_2$ and U(nat)O_2 fuel pins immersed in water
MIX-COMP-THERM-002	6					6	mixed $^{239}PuO_2$ and U(nat)O_2 fuel pins immersed in water or borated water
MIX-COMP-THERM-003	6					6	rectangular arrays of mixed $^{239}PuO_2$ and U(nat)O_2 fuel pins immersed in water
MIX-COMP-THERM-004	11						arrays of mixed $^{239}PuO_2$ and U(nat)O_2 fuel rods immersed in water
MIX-COMP-THERM-005	7		1		1		hexagonal lattice arrays of mixed $^{239}PuO_2$ and U(nat)O_2 fuel pins immersed in water
MIX-COMP-THERM-006	6		1		1		hexagonal lattice arrays of mixed $^{239}PuO_2$ and U(nat)O_2 fuel pins immersed in water
MIX-COMP-THERM-007	27		27		27		five lattices of mixed $^{239}PuO_2$ and U(nat)O_2 rods in water, incl Hf/B/Cd rod substitutions
MIX-COMP-THERM-008	28		28		28	28	six lattices of mixed $^{239}PuO_2$ and U(nat)O_2 rods in water, incl Hf/B/Cd rod substitutions
MIX-COMP-THERM-009	6		1		1	6	hexagonal lattices of mixed $^{239}PuO_2$ and U(dep)O_2 fuel pins immersed in water
MIX-COMP-THERM-010	0	n/a	n/a			n/a	refer to MIX-MISC-THERM-001
MIX-COMP-THERM-011	6		1		1	6	arrays of mixed $^{239}PuO_2$ and U(60)O_2 fuel rods immersed in water
MIX-COMP-THERM-012	33		33		33	33	bare and Plexiglas reflected arrays of MOX/polystyrene blocks
MIXED ENERGY MIXED PU-U COMPOUND SYSTEMS							
none presently evaluated							
MIXED PU-U SOLUTION SYSTEMS							
INTERMEDIATE ENERGY MIXED PU-U SOLUTION SYSTEMS							

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments
Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual							
none presently evaluated							
THERMAL ENERGY MIXED PU-U SOLUTION SYSTEMS							
MIX-SOL-THERM-001	13		13		13	13	^{239}PuNH + U(nat)NH soln in annular geomerty
MIX-SOL-THERM-002	3		3		3	3	^{239}PuNH + U(nat)NH soln in large cylindrical geomerty
MIX-SOL-THERM-003	10					10	^{239}PuNH + U(nat)NH soln in cylindrical geomerty with poly/water refl
MIX-SOL-THERM-004	9		9		9	9	^{239}PuNH + U(dep)NH soln in small cyl geom, bare or water or concrete refl
MIX-SOL-THERM-005	7		7		7	7	^{239}PuNH + U(dep)NH soln in slab geomerty, bare or water refl
MIXED ENERGY MIXED PU-U SOLUTION SYSTEMS							
none presently evaluated							
MIXED PU-U MISCELLANEOUS SYSTEMS							
FAST ENERGY MIXED PU-U MISCELLANEOUS SYSTEMS							
none presently evaluated							
INTERMEDIATE ENERGY MIXED PU-U MISCELLANEOUS SYSTEMS							
none presently evaluated							
THERMAL ENERGY MIXED PU-U MISCELLANEOUS SYSTEMS							
MIX-MISC-THERM-001	11		11		11	11	mixed oxide fuel pin lattices in (Pu+U)NH solution
MIX-MISC-THERM-002	12						arrays of mixed $^{239}PuO_2$ and $U(60)O_2$ fuel rods in dilute ^{239}PuNH soln and refl by water
MIXED ENERGY MIXED PU-U MISCELLANEOUS SYSTEMS							
none presently evaluated							
Volume VII, Special Isotope Systems							
SPECIAL ISOTOPE METAL SYSTEMS							

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments

Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual

FAST ENERGY SPECIAL ISOTOPE METAL SYSTEMS

SPEC-MET-FAST-001	4						replacement measurements of ^{240}Pu Jezebel with void, U(93), ^{239}Pu, or ^{244}Cm
SPEC-MET-FAST-002	3						replacement measurements of ^{240}Pu Jezebel with void, ^{238}Pu, or ^{239}Pu
SPEC-MET-FAST-003	6						replacement measurements of Flattop (Pu and HEU) with void, ^{237}Np, or U(93)
SPEC-MET-FAST-004	7						combos of ^{239}Pu, ^{242}Pu, and U(93) metal disks, unrefl and refl by steel, Be, or U(dep)

INTERMEDIATE ENERGY SPECIAL ISOTOPE METAL SYSTEMS

none presently evaluated

THERMAL ENERGY SPECIAL ISOTOPE METAL SYSTEMS

none presently evaluated

MIXED ENERGY SPECIAL ISOTOPE METAL SYSTEMS

none presently evaluated

SPECIAL ISOTOPE COMPOUND SYSTEMS

FAST ENERGY SPECIAL ISOTOPE COMPOUND SYSTEMS

none presently evaluated

INTERMEDIATE ENERGY SPECIAL ISOTOPE COMPOUND SYSTEMS

none presently evaluated

THERMAL ENERGY SPECIAL ISOTOPE COMPOUND SYSTEMS

none presently evaluated

MIXED ENERGY SPECIAL ISOTOPE COMPOUND SYSTEMS

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments

Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual

none presently evaluated

SPECIAL ISOTOPE SOLUTION SYSTEMS

FAST ENERGY SPECIAL ISOTOPE SOLUTION SYSTEMS

none presently evaluated

INTERMEDIATE ENERGY SPECIAL ISOTOPE SOLUTION SYSTEMS

none presently evaluated

THERMAL ENERGY SPECIAL ISOTOPE SOLUTION SYSTEMS

none presently evaluated

MIXED ENERGY SPECIAL ISOTOPE SOLUTION SYSTEMS

none presently evaluated

SPECIAL ISOTOPE MISCELLANEOUS SYSTEMS

FAST ENERGY SPECIAL ISOTOPE MISCELLANEOUS SYSTEMS

none presently evaluated

INTERMEDIATE ENERGY SPECIAL ISOTOPE MISCELLANEOUS SYSTEMS

none presently evaluated

THERMAL ENERGY SPECIAL ISOTOPE MISCELLANEOUS SYSTEMS

none presently evaluated

MIXED ENERGY SPECIAL ISOTOPE MISCELLANEOUS SYSTEMS

System Type	Acceptable benchmarks in the 2002 OECD Manual	KENO V.a models included in Y/DD-896 Rev 0	KENO V.a models included in Y/DD-996 Rev 1	KENO V.a models added for Y/DD-896 Rev 1	KENO V.a Totals	MCNP4C2 models included in Y/DD-1026 Rev 0	General Description/Comments

Highlighted text indicates additions/changes to Volumes I, II, III, IV, and VII since the 2001 OECD Manual

none presently evaluated

qual
other
mix

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Determination of the Upper Subcritical Limit for Criticality Calculations for Criticality Safety Analyses

Revision 1

R. H. Smith

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Y-12 National Security Complex

Y-12 NATIONAL SECURITY COMPLEX

August 2003

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Y/DD-972R1

Determination of the Upper Subcritical Limit for Criticality Calculations for Criticality Safety Analyses

Revision 1

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August 2003

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Abstract

This report considers determination of an upper subcritical limit, and incorporating uncertainty and margin into the subcritical limit, and recommends an Upper Subcritical Limit (USL).

A USL is developed for CSAS25 from SCALE4.4a. The USL is applicable for the CSAS25 control module from the SCALE 4.4a computer code system for use in evaluating nuclear criticality safety of enriched uranium systems. The benchmark calculation results used for this report are documented in Y/DD-896/R1. The 238-group ENDF/B-V cross-section libraries were used.

Numerical methods for applying margins are described, but the determination of appropriate correlating parameters and values for additional margin, applicable to a particular analysis, must be determined as part of a process analysis. As such, this document does not specify final upper subcritical limits as has been done in the past. No correlation between calculation results and neutron energy causing fission was observed for the critical experiment results. Analysts using these results are responsible for exercising sound engineering judgment using strong technical arguments to develop "a margin in k_{ef} or other correlating parameter ... that is sufficiently large to ensure that conditions (calculated by this method to be subcritical by this margin) will actually be subcritical." [1] Documentation of area of applicability and determination and justification of the appropriate margin in the analyst's evaluation, in conjunction with this report, will constitute the complete Validation Report in accordance with ANSI/ANS-8.1-1998, Section 4.3.6(4).

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1 Introduction

In the nuclear criticality safety field, extensive use is made of computational methods in order to establish subcritical limits for operations involving fissile material. Calculations must be made by a method shown to be validated by comparison with experiment data. The American National Standards Institute (ANSI) gives fundamental guidance for establishing these subcritical limits in ANSI/ANS-8.1-1998, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors."[1]

The successful application of computational methods requires verification, certification and validation (V&V) of the analytic tool. Software verification, the first element of V&V, reveals the closeness in agreement between calculation results obtained using a particular computational method and calculation results obtained using other methods. Software certification provides a user assurance that the code will consistently produce numerical results that agree with analytic solutions for the problems the code is designed to analyze. Software validation "calibrates" the calculation results obtained using certified software (computational method) for agreement with the physical universe.

For nuclear criticality safety, the validation process is complete with development of the upper subcritical limit (USL) from validation data. Refinement of a validation or extension by addition of validation data does not require re-certification of the software. Therefore, the verification and certification of a nuclear criticality safety computer code system and transference of a validation between computer platforms are related issues, which can be addressed separately from software validation.

Taken together, Y/DD-896/R1 and Y/DD-972/R1 provide the **framework** for the validation of CSAS25 control module from the Standardized Computer Analyses for Licensing Evaluation (SCALE) Version 4.4a package with the 238-group ENDF/B-V SCALE 4.4a cross-section library.

Y/DD-896/R1 addresses the establishment of bias, bias trends and uncertainty associated with the use of SCALE4.4a for performance of criticality calculations. This evaluation is directed at all systems consisting of fissile and fissionable material in metallic, solution and other physical forms, as described in the Organization for Economic Cooperation and Development (OECD) Benchmark Handbook. The focus is on comparison of calculated neutron multiplication factors (k_{eff}) with the associated experimental benchmark results, and on establishment of bias, bias trends, and uncertainty as a final step. Compiled data for 1217 critical experiments is used as the basis for the calculation models. The calculated results from SCALE 4.4a using the 238-group ENDF/B-V SCALE 4.4a cross-section library have been compared with reported results for the benchmark experiments. Comparison of results demonstrates that SCALE 4.4a run on the Nuclear Criticality Safety Division (NCSD) Hewlett Packard Series 9000/J-5600 (HP J-5600) unclassified workstation (referred to as CMODB) produces the same results within the

statistical uncertainty of the Monte Carlo calculations as reported by the experiments.

Y/DD-972 addresses various methods for determination of a USL and for incorporating uncertainty and margin into this USL. It provides comparisons of these methods and recommends a preferred method for determining the USL. Y/DD-972 establishes subcritical limits determined through an evaluation of statistics parameters of calculation results for critical experiments. However, the correlating parameters (i.e., mass, enrichment, geometry, absorption, moderation, reflection, etc.) and values for applying additional margin to the subcritical limits are application dependent. The determination of correlating parameters and additional margin is an integral part of the process analysis for a particular application. For the critical experiment results, no correlation between calculation results and neutron energy causing fission was found. As such, this document does not specify "final" USL values as has been done in the past.

The Area of Applicability (AoA) is also application dependent. In using the "raw" USL data of this report, the nuclear criticality safety analyst must exercise sound engineering judgment and use strong technical arguments to develop a margin in k_{eff} or other correlating parameter. That margin must be sufficiently large to ensure that conditions (calculated by this method to be subcritical by this margin) will actually be subcritical.[1] Preparation of this final portion of the "written report of validation" as identified in Section 4.3.6 of ANSI/ANS-8.1-1998 is the responsibility of the analyst.

1.1 Grandfather or Retrofit Concerns

The validation documents used for establishing subcritical limits for criticality calculations shall be reviewed and approved by NCSD. There is no urgency to retrofit older evaluations since the common practice provided conservatism. Therefore, the incorporation of these newer results and methods into the evaluations of existing operations will be accomplished as the Nuclear Criticality Safety Approvals are updated due to equipment changes, rule changes, age, etc.

1.2 Terminology

The term "model" may be used in two different ways. In this report, "model" generally refers to the calculation model, or the collection of input parameters for the numerical simulation of the physical critical experiment. In statistical analyses, the term "model" generally refers to a statistical model, or an equation describing the relationship between parameters considered in the statistical analysis.

The term "uncertainty" may also be used two different ways. In this report, "uncertainty" generally refers to less than exactly known values in the calculation model, or in the collection of input parameters for the numerical simulation of the physical critical experiment. In statistical analyses, the term "uncertainty"

generally refers to the variation of repeated observations (e.g., k_effective or k_simulation) about their expected value. This uncertainty is quantified by the sample standard deviation (i.e., square root of the sample variance).

Accuracy refers to how close the expected value of an observation is to the true value. Accuracy is quantified by bias, which is the difference between the sample average and the true or referenced value.

2 Subcritical Limits and Statistical Analysis

2.1 Introduction

Y/DD-896/R1 provides a discussion of the calculation results, experiment (benchmark) data, and the bias results. Regression with neutron energy causing fission was observed to be not applicable. This is illustrated in Figures 1-7 of Y/DD-896/R1.

The OECD Handbook provides an estimate of the actual k_{eff} for each experiment benchmark. While most experiments were estimated to be exactly critical, or k_exp = 1.0, a number of the estimates were slightly above or slightly below exactly critical (i.e. k_exp > 1.0 or k_exp < 1.0). It was considered desirable to account for this difference because the subcritical limit could otherwise be conservative due to including slightly subcritical experiments, or non-conservative due to including slightly super-critical experiments. The following adjustment, to determine an adjusted calculation result, k', was proposed for use in the statistical evaluation:

$$k' = 1 + bias = 1 + (k_calc - k_exp)$$

where k_calc = code calculated k_{eff} result for the modeled experiment, and
k_exp = OECD estimate of actual k_{eff} for the experiment

The assumption inherent in making this adjustment is that the experiments were close to critical, and if a very small adjustment could be made so that the experiment would be exactly critical, the bias of the calculation would not change.

When calculation methods are employed, the subcritical limit is a quantitative value used for implementation of NCSD policy, which is established in accordance with DOE Orders, Standards, or by NRC regulations for those activities under NRC jurisdiction. Evaluation criteria are usually the calculated reactivity, k_{eff}, for the model of the problem being evaluated, uncertainty in the calculated value of reactivity, bias introduced by the code used to calculate reactivity, and bias introduced by the model. Code bias is determined by a validation performed in accordance with ANSI/ANS 8.1. The statistical results in this

report determine code bias based on comparison of code calculations with experimental results. Model bias is due to uncertainties in the modeled parameters describing the problem, approximations made for the model to conform to the input requirements of the code, and any significant simplifications of the problem introduced into the model by the analyst. The acceptance criterion requires that the evaluation criteria be bounded by the subcritical limit. In the case of code calculations, the subcritical limit is often a criterion based on calculated k_{eff} and estimated bias and uncertainties.

It is recognized that it may also be possible to determine subcritical limits based on adjustment of correlating parameters other than k_{eff}, as allowed by ANSI/ANS-8.1. These parameters could include physical parameters such as mass or radius, for example, or other calculated parameters besides k_{eff}, if they can be shown to provide a subcritical margin. This report does not address other potential correlating parameters, but an analyst could determine them as part of an evaluation and use them to determine subcritical limits in conjunction with the code bias results in this report.

2.2 Determination of Subcritical Limits from the Bias and Uncertainty

Several methods could be used for determination of subcritical limits in terms of calculated k_{eff}. The methods were discussed in more detail in previous revisions, and the discussion will not be repeated here. Another reference is NUREG/CR-6698[2]. As discussed above, and in Section 5.1 of Y/DD-896/R1, it may also be possible to determine subcritical limits based on adjustment of correlating parameters other than k_{eff}, but this approach is not addressed here.

2.2.1 Area of Applicability

Whether a particular plant application is similar to a sufficient number of experiments contained in the validation set is an important issue. This is a prerequisite before a subcritical limit may be determined from the validation results. Based on the demonstrated performance of the code for a large number of experiments, we have reasonable assurance that it performs well over a wide range of conditions. However, this does not ensure that the code performs as well over all conditions and several conditions where the code performed very poorly were listed in Section 5.3 of Y/DD-896/R1. There may be other scenarios where the code would calculate unusually low, or high, due to some kind of anomaly or error in the code or cross section data. In addition, there are some types of experiments that are few of a kind. It is possible that there could be one or more of these types of experiments that would exhibit a larger bias than seen in this report, if more experiments of that type were included. The only way to assess whether the validation set contains a sufficient number of experiments that are similar to a plant application is to carefully compare the details of the experiment descriptions with the details of the plant application. The broad categories used for the statistical analysis may not be sufficient for making the determination, and the

experiment summary information included in these reports may not provide enough information. The analyst must become familiar with the experiment descriptions provided in the OECD handbook. The minimum number of similar experiments needed cannot necessarily be determined in advance, but the analyst must consider this issue carefully as one of the factors when deciding how much margin to include in determining a subcritical limit. The recommendations in Reference 2 may be useful in this regard. If there are only a few experiments similar to the application, it may be wise to recommend taking the time to select additional applicable experiments for addition to the validation set, or for a separate evaluation.

Appropriateness of the subcritical limit does not depend solely on the validity of the statistical analysis. Rather, the appropriateness of a subcritical limit depends on two quite different factors: (1) the range of conditions under which a generalization for its use is established, and (2) whether or not the modeled scenario is within the range of these conditions. The nuclear criticality safety analyst, exercising sound engineering judgment using strong technical arguments, must develop these determinations. Extrapolation beyond the range of applicability should not be done.

2.2.2 Simple Methods for Determination of Subcritical Limits

The simplest and most straightforward method is to observe that for a large number of critical (or close to critical) experiments, calculated results were relatively consistent, and none were lower than a particular minimum. A value of k_{eff} could be picked that is at or slightly below all the calculated results. Combined limits could be used for simplicity as long as the minimum values were used. The minimum value is established by a single case. These values do not include any reduction for numerical uncertainty in the calculated mean value for the case (standard deviation of approximately 0.001). The minimum k_{eff} value would be reduced further to provide additional margin as appropriate as determined by the analyst.

Another similar method to establish a subcritical limit would be to choose the lowest (i.e. least positive or most negative) bias result, add it to 1.0, and reduce this value by an additional amount to allow for a margin of safety. The results of this approach (without reduction for margin of safety) are shown in Table 1. These values do not include any reduction for numerical uncertainty in the calculated mean value for the minimum case. This is the method chosen for this report.

2.2.3 Addition of Safety Margin and Bias Based on Tolerance Bounds

In the commonly used relationship of procedure Y70-68-005, the subcritical limit appears in Equation 2.1 as the term on the right while the evaluation criteria of a given problem are expressed in the term on the left. It is recognized that, depending on how the terms are defined, this approach may mix confidence intervals (k_{eff} + 2s) and tolerance limits (1.0 - bias - margin) in a semi-statistical formula or

method. Acceptability is established when the term on the left is less than or equal to the term on the right:

$$\{ k_{eff} + 2s + \text{code bias} + \text{model bias} \} <= \{ 1.0 - \text{margin of safety} \} \quad \text{(Eq 2.1)}$$

Code bias is determined by a validation performed in accordance with ANSI/ANS 8.1. The statistical results in this report present bias based on comparison of code calculations with experimental results. Some regulators require that when the mean value of calculated k_{eff} for the validation cases is greater than or equal one, then the code bias is set = 0.

Model bias is due to uncertainties in the modeled parameters describing the problem, approximations made for the model to conform to the input requirements of the code, and any significant simplifications of the problem introduced into the model by the analyst.

Margin of safety is set by NCSD analysts in accordance with DOE Orders, Standards, and NRC Regulations for activities under these specific jurisdictions (and possibly to allow for uncertainty or limitations in area of applicability relative to the analyzed configuration). A typical range is from 0.02 to 0.05. When the analyst feels there is very little uncertainty in the application, it may be possible to justify using lower margin of safety. Also, it may be appropriate to provide margin by adjustment of correlating parameters other than k_{eff}.

2.2.3.1 Treatment of Model Bias

For calculation models that are accurate representations, the model bias is considered zero. For calculation models with uncertainties in the modeled parameters describing the problem, model bias is intended to compensate for the uncertainty in the calculated k_{eff} due to the uncertainty in the dominant parameter(s) of the problem. Quantitatively, model bias is determined by evaluating k_{eff} of problem "A" as a function of the parameter "p" over the range of uncertainty in "p" [expressed here as x%], i.e., calculations performed with the parameter "p" set at values between "p(1-x%/100)" and "p(1+x%/100)" to establish the corresponding uncertainty in k_{eff}. Values at and between both extremes must be considered because reactivity may not be uniformly distributed about the parameter "p". The number of values to be evaluated depends on the magnitude of the range in the parameter. The model bias for parameter(s) "p" used in the above equation is the absolute value of the maximum difference:

$$| \; k_{eff}\{\text{"p_max"}\} - k_{eff}\{\text{"p_min"}\} \; |,$$

Where $k_{eff}\{\text{"p_max"}\}$ = maximum k_{eff} over the range of parameter(s) "p"
$k_{eff}\{\text{"p_min"}\}$ = minimum k_{eff} over the range of parameter(s) "p"

The maximum variation in k_{eff} over the ranges of uncertainty of all dominant parameters of the problem would be used as the model bias in Equation 2.1. Allowance for statistical uncertainty in the calculated results must be considered, depending on the relative magnitude. If the parameter of interest is a discrete or categorical variable rather than a continuous variable as discussed above, then the parameter would similarly be varied over the range of applicable states until the maximum variation was found.

An allowance for model bias could otherwise be included in the margin of safety as shown in Eq. 2.2:

$$\{ k_{eff} + 2s + \text{code bias} \} <= \{ 1.0 - \text{margin of safety*} \} \quad \text{(Eq 2.2)}$$

This would require justification that the evaluation criteria (left side of Eq. 2.2) is sufficiently less than 1.0 by an amount out weighing the maximum variation of k_{eff} for the dominant parameters affecting reactivity.

For calculation models with a significant degree of approximation and simplification, model bias is intended to account for conservatism built into the model. Generally, the model bias is not explicitly calculated, but is addressed by modeling parameters at their worst case. Establishment of the worst case may require a parametric study as described previously. An allowance for model bias would be included in the margin of safety (term on right side of Eq. 2.2). This would require justification that the evaluation criteria (left side of Eq. 2.2) is sufficiently less than 1.0 by an amount that out weighs the conservatism built into the calculation model.

2.2.4 Statistical Approach

Non-parametric statistics are used in this report. According to Reference 2, Section 2.4.4, attaining typical 95% confidence of 95% of the population being above the smallest data sample requires only 59 experiments. After excluding the three lowest results in Table 5.1 of Y/DD-896/R1, due to being infinite models with relatively large amounts of chromium, nickel, zirconium or stainless steel, there are 1214 remaining experiments. It could be stated that there is greater than 99.999% confidence that 99% of the population is above the remaining smallest data sample (1-0.99^1214 = 0.9999949). In the 1214 remaining calculations for this report, the smallest adjusted k-effective was 0.96649 (for a U-233 benchmark).

2.2.5 Discussion of Results

Based on the methods discussed previously, the following subcritical limits are recommended:

Table 1. Upper Subcritical Limits (Before subtraction of any additional margin)

Fissile Category	Number of Cases	Upper Subcritical Limit
Combined category for HEU, IEU, LEU	639	0.975 (Note 1)
Plutonium or Mixed Pu-U	438	0.971
Uranium-233	140	0.966
All Categories Combined	1217	0.966

Note 1: Experiment Series HEU-COMP-INTER-005, cases 7,9, 15 and 16 showed that particular caution should be used with large arrays with large amounts of nickel, chromium, zirconium or stainless steel. These results indicated a potential for limits in the 0.856 to 0.968 range.

This recommendation is subject to the following restrictions:

- Models must be similar to those included in the benchmarks (See especially Table 3.1 of Y/DD-896/R1 for a concise summary).
- Models must not be similar to the cases with high negative bias described in Table 5.1 of Y/DD-896/R1. Characteristics include large amounts of chromium, nickel, zirconium or stainless steel, and infinite models, or very large models with little leakage, in which absorption in the listed materials is a major influence on the results. Iron and stainless steel are also materials that contributed to poor performance of the code, and care should also be taken with models having large amounts of iron or stainless steel (or stainless steel's component materials).
- Models must use options, materials and arrangements that have been included in the benchmarks.
- The upper subcritical limits stated above include only code bias. No additional margin is included for model bias (simplifications or uncertainties in analyzed conditions) or additional margin of safety. **A larger or smaller additional margin may be applicable depending on the plant process analysis, and the analyst must justify the amount of the applied margin in the process analysis.**

With 1214 experiments (of 1217 total) included in the determination of the subcritical limit, there is a good basis for having very high confidence that systems and conditions (similar to those included in this report) calculated by this method to be subcritical, will actually be subcritical. Allowance for additional margin for model bias, safety margin or area of applicability margin, if needed, would be subtracted from this upper subcritical limit. Additional margins of 0.02 to 0.05 have typically been used; however, the appropriate value depends on the details of the analysis, and administrative policy, if any. In determining these upper subcritical limits, the systems were not sub-divided into detailed categories based on materials and forms. Rather, a conservative value based on all the results for each fissile species has been determined. A combined limit is also given.

The 238-group library is the only one included in this report. Based on Reference 3 there may be some applications where the 44-group library may perform better (Low Enriched LWR and MOX lattices, and ^{233}U), but this has not been evaluated in this report.

Although four or more decimal places are shown in results tables (Y/DD-896/R1), the actual accuracy of the code, for a particular calculation, may be on the order of +/- 0.02 to 0.03 (or more) based on the spread in the bias results. Also, the standard deviation of the mean for a particular calculation was on the order of 0.001 for benchmark cases, and may be somewhat higher for applications. Therefore, less than four decimal places are physically meaningful or significant for developing limits. Too much importance should not be placed on small differences in the third or fourth decimal place. The main value of reporting four (or five) decimal places for a calculation result is to confirm that the result reported actually originated from a given output file.

Non-parametric statistics was used exclusively in this report.

3 Conclusions

Taken together, Y/DD-896/R1 and Y/DD-972/R1 provide the **framework** for the validation of CSAS25 control module from the Standardized Computer Analyses for Licensing Evaluation (SCALE) Version 4.4a package with the 238-group ENDF/B-V SCALE 4.4a cross-section library.

Y/DD-896/R1 addresses the establishment of bias, bias trends and uncertainty associated with the use of SCALE4.4a for performance of criticality calculations. This evaluation is directed at systems consisting of fissile and fissionable material in metallic, solution and other physical forms, as described in the OECD Handbook. The focus is on comparison of calculated neutron multiplication factors (k_{eff}) with the associated experimental results, and on establishment of bias, bias trends, and uncertainty as a final step. Compiled data for 1217 critical experiments is used as the basis for the calculation models. The calculated results from SCALE 4.4a using the 238-group ENDF/B-V SCALE 4.4a cross-section library have been compared with reported results for the benchmark experiments. Comparison of results demonstrates that SCALE 4.4a run on the Nuclear Criticality Safety Division (NCSD) Hewlett Packard Series 9000/J-5600 (HP J-5600) unclassified workstation (referred to as CMODB) produces the same results within the statistical uncertainty of the Monte Carlo calculations as reported by the experiments.

Y/DD-896/R1 provides assurance that the code predicts critical systems reasonably well, however, in general, there is wide variation in performance depending on the type of system, based on bias results. Using a rating scale similar to Reference 3, the performance ranges from "very good" or less than about +/- 0.01 to "very poor" or about +0.087/-0.14, depending on the category of experiments. In general, the previously observed problems resulted in very high bias, which would be conservative for plant applications.

This report includes several benchmark cases that significantly under-predict the expected results. There is no guarantee against the possibility of an unusual scenario that could produce non-conservative results, and analysts must be always vigilant for this possibility.

Y/DD-972/R1 recommends a preferred method for determining the upper subcritical limit. Y/DD-972/R1 establishes subcritical limits determined through an evaluation of statistics parameters of calculation results for critical experiments. However, the correlating parameters (i.e., mass, enrichment, geometry, absorption, moderation, reflection, etc.) and values for applying additional margin to the subcritical limits are application dependent. The determination of correlating parameters and additional margin is an integral part of the process analysis. For the critical experiment results, no correlation between calculation results and neutron energy causing fission (or any other parameter) was observed. As such, this document does not specify final upper subcritical limit values as has been done in the past.

The Area of Applicability (AoA) is also application dependent. In using the oraw" upper safety limit data of this report, the criticality analyst must exercise sound engineering judgment and use strong technical arguments to develop "a margin in k_{eff} or other correlating parameter. The margin must be sufficiently large to ensure that conditions (calculated by this method to be subcritical by this margin) will actually be subcritical.[1]

Documentation of determination and justification of the appropriate margin in the analyst's evaluation, in conjunction with this report, will constitute the complete Validation Report in accordance with ANSI/ANS-8.1-1998, Section 4.3.6(4).

4 Recommendations for Future Work

As stated in Y/DD-896/R1, numerous additional OECD experiment descriptions are already available for experiments that would be directly applicable to Y-12 applications. In this regard, future efforts should be dedicated to the following: (1) developing more input decks in-house for experiments selected based on applicability to Y-12, and (2) including additional models as they become available in future revisions of the OECD report. In addition, changes in experiment categorization and interpretation, and clarifications are sometimes reported in the annual revisions of the OECD handbook. These changes should be reviewed to determine whether they impact the conclusions in this report. This work will require a dedicated effort.

Additional work may be needed to identify trends and/or biases by including additional parameters in the statistical evaluation of critical experiment results.

Additional work is needed on Area of Applicability (AoA) determination methods. Determining whether a particular application is within the AoA of a validation is currently almost exclusively based on subjective judgment. To be done correctly, it requires the analyst to have close familiarity with the details of the experiments in the validation. Efforts to develop input models for more experiments, particularly if done by several staff members, would have the additional benefit of increasing staff's familiarity with experiment descriptions, which would also help improve these AoA determinations. Continuing to do such model input preparation work as part of the qualification program (and re-qualification) is suggested. In addition, methods have been proposed for more rigorous, and quantitative, AoA determinations. A dedicated effort is needed to evaluate these methods to determine if they are effective and practical to implement.

As discussed in Y/DD-896/R1, based on the bias results, areas of relatively poor performance are seen, probably due to cross section data issues. Efforts to produce improved cross section libraries for SCALE should be supported.

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